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DARLINGTON LEAK BEFORE BREAK J-RESISTANCE CURVE - TEST VERIFICATION PROGRAM

Report No. 87-262-K

B. Mukherjee
Nondestructive and Fracture Evaluation Section
Metallurgical Research Department

ABSTRACT

In the Darlington Leak-Before-Break material test program, J-resistance curves were determined from actual Darlington NGS-A large diameter heat transport piping, forgings, associated welds and heat affected zones. Because of the importance of the material test results to the Darlington LBB program, it was decided to validate the material test method by comparing six Ontario Hydro test results against tests conducted by an independent laboratory. Materials Engineering Associates of Lanham, Maryland was selected for conducting the validation tests, because of their experience in conducting single specimen J-resistance curve tests for US Nuclear Regulatory Commission and Electric Power Research Institute. The J_{Ic} values and J resistance curves obtained by Ontario Hydro and MEA were comparable.

job	file	date	report no.
83-153-451	826.2	December 1, 1987	87-262-K

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EXECUTIVE SUMMARY

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In the Darlington Leak-Before-Break material test program, J-resistance curves were determined from actual Darlington NGS-A large diameter heat transport piping, forgings, associated welds and heat affected zones. Because of the importance of the material test results to the Darlington LBB program, it was decided to validate the material test method by comparing six Ontario Hydro test results against tests conducted by an independent laboratory. Materials Engineering Associates of Lanham, Maryland was selected for conducting the validation tests, because of their experience in conducting single specimen J-resistance curve tests for US Nuclear Regulatory Commission and Electric Power Research Institute. The J_{Ic} values and J resistance curves obtained by Ontario Hydro and MEA were comparable.

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ontario hydro
research division

To

Mr. M.A. Machacek
Manager of Engineering - Darlington GS
Design and Construction

DARLINGTON LEAK BEFORE BREAK
J-RESISTANCE CURVE - TEST VERIFICATION PROGRAM

1.0 INTRODUCTION

Ontario Hydro has developed a leak-before-break (LBB) methodology for application to the large diameter heat transport piping for Darlington NGS-A as a design alternative to pipewhip restraints and in recognition of the questionable benefits of providing such restraints. Ontario Hydro's leak-before-break approach is based on the J/T method/1/. The material value of J associated with crack extension, which is also known as material resistance curve or a J-R curve is required for stability assessment in this approach. In the Darlington leak-before-break material test program, J-R curves were determined from actual Darlington NGS-A large diameter heat transport piping, forgings, associated welds and heat affected zones. Altogether, 85 tests were conducted in this test program. Results of these tests have been reported in /2/. Because of the importance of the material test results to the Darlington LBB program, it was decided to validate the material test method by comparing six test results against tests conducted by an independent laboratory. Materials Engineering Associates of Lanham, Maryland was selected for conducting the validation tests, because of their experience in conducting single specimen J-resistance curve tests for US Nuclear Regulatory Commission/3/ and Electric Power Research Institute/4/.

2.0 MEA TEST PROGRAM

Six IT-CT specimens were machined by MEA. Material was supplied by Ontario Hydro as saw cut blanks marked with specimen orientation. Specimens J86, J87 and J88 were machined from a 22" NPS Sch 100 SA106 B pipe (coupon number N5). Specimens J89, J90 and J91 were machined from a circumferential PN-107 weld joint. Two coupons, C5 and C8, were used for the weld specimens. All specimen orientations were longitudinal-circumferential (L-C).

All specimens were fatigue precracked, side grooved (10% each side) and tested at 250°C in accordance with ASTM E813-81/5/ and ASTM draft R-curve procedures/6/. Yield and ultimate strengths at 250°C were provided by Ontario Hydro.

A comprehensive report was produced by MEA documenting their test method and all test results. It is appended to this report as Appendix A.

3.0 COMPARISON OF TEST RESULTS

A comparison of J_{Ic} values between the OH and MEA tests are shown in Figure 1. J-resistance curves are compared in Figures 2 and 3. With the exception of one MEA test, which produced a high J_{Ic}, all OH and MEA J_{Ic} values of 22" NPS Sch 100 parent material were comparable (Figure 1). The MEA J-resistance curves for the parent material were slightly higher than the OH J-resistance curves. A comparison of Figure 2 with all parent material tests conducted by Ontario Hydro (Figure 4) suggests that the MEA J-Resistance curves lie within the observed scatterband of all parent material tests.

J_{Ic} values obtained by OH and MEA on PN-107 weld at 250°C were also comparable (Figure 1). Three OH J-resistance curve tests on PN-107 weld lie within the band created by 3 MEA tests (Figure 3). The lower bound of this band is created by two tests, one each from MEA and OH.

Considerable care was exercised by Ontario Hydro in checking transducer calibration and computer programs that were developed for data analysis of single specimen J_{Ic} tests. This comparison with MEA provided an independent but indirect validation of transducer calibration, test method and crack length and J calculation algorithms. In summary, the J_{Ic} and J-resistance curves obtained by OH and MEA on parent and weld material were comparable. There was no systematic variation or discrepancy between the tests conducted by two independent laboratories.

4.0 CONCLUSIONS

The material test method for J-resistance curves was validated by comparing six test results against similar tests conducted by Materials Engineering Associates of Lanham, Maryland. The J_{Ic} values and J-resistance curves obtained by Ontario Hydro and MEA were comparable.

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1. B.L. Kee and J.S. Nathwani, "Darlington NGS A Leak-Before-Break Approach for Large Diameter Heat Transport (HT) Piping", Ontario Hydro Design and Development Division Report No. 85371, December, 1985.

2. B. Mukherjee and D. Carpenter, "Darlington Leak Before Break Material Test Program, J-Resistance Curves, Volume I, General Summary, Discussion of Results and Conclusions", Ontario Hydro Research Division Report No. 83-232-K.

3. "Structural Integrity of Water Reactor Pressure Boundary Components", Annual Report for 1984. Edited by F.J. Loss, Materials Engineering Associates, NUREG/CR-3228, MEA-2051, Vol. 3.

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5. E813-81, Standard Test Method for J_{Ic}, A Measure of Fracture Toughness. 1985 Annual Book of ASTM Standards.

6. Standard Test Method for Determining J-R Curves, 12th Draft. A proposed test method developed by the ASTM E24.08 Subcommittee.

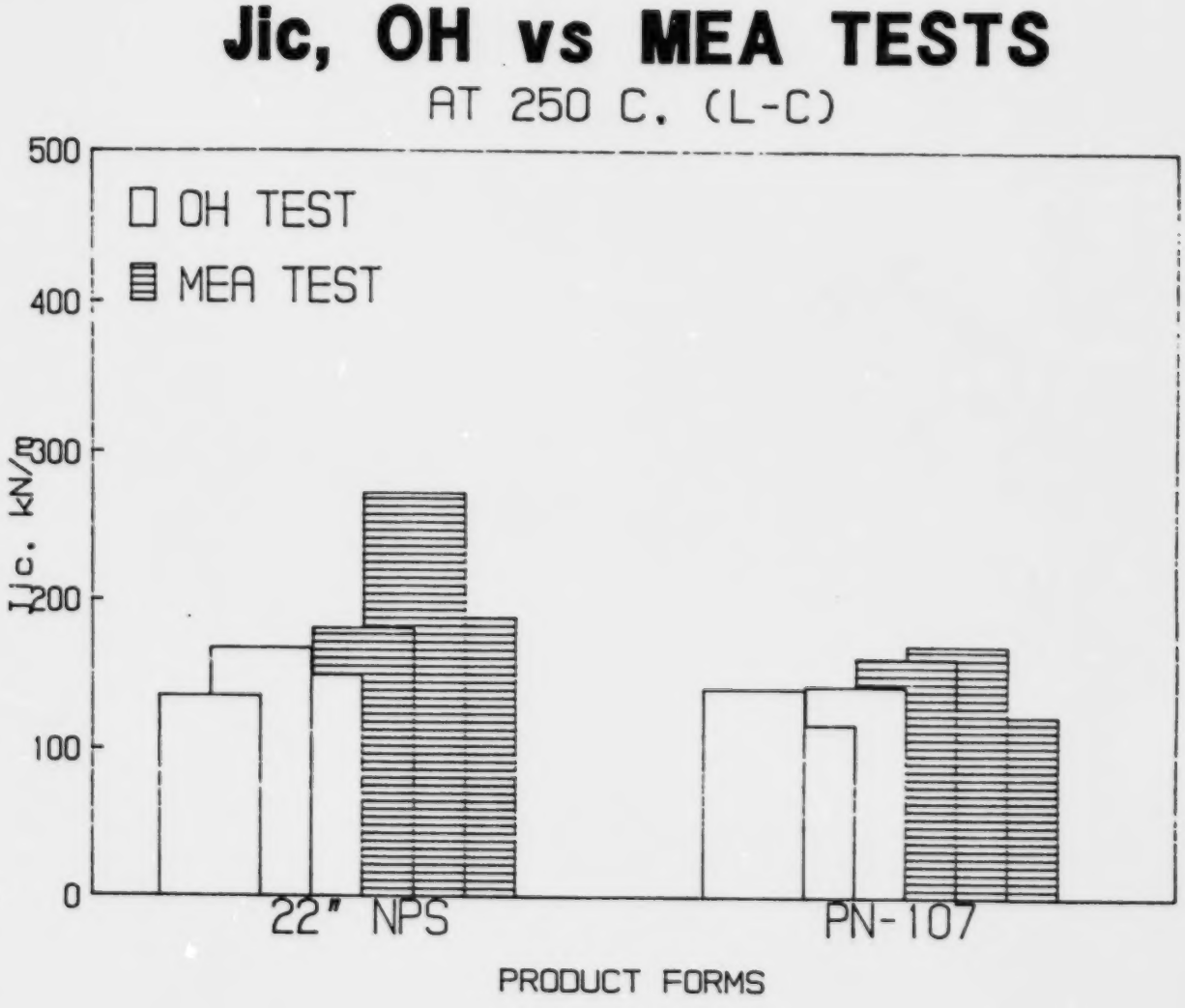

FIGURE 1

COMPARISON OF J_{IC} VALUES BETWEEN OH AND MEA TESTS

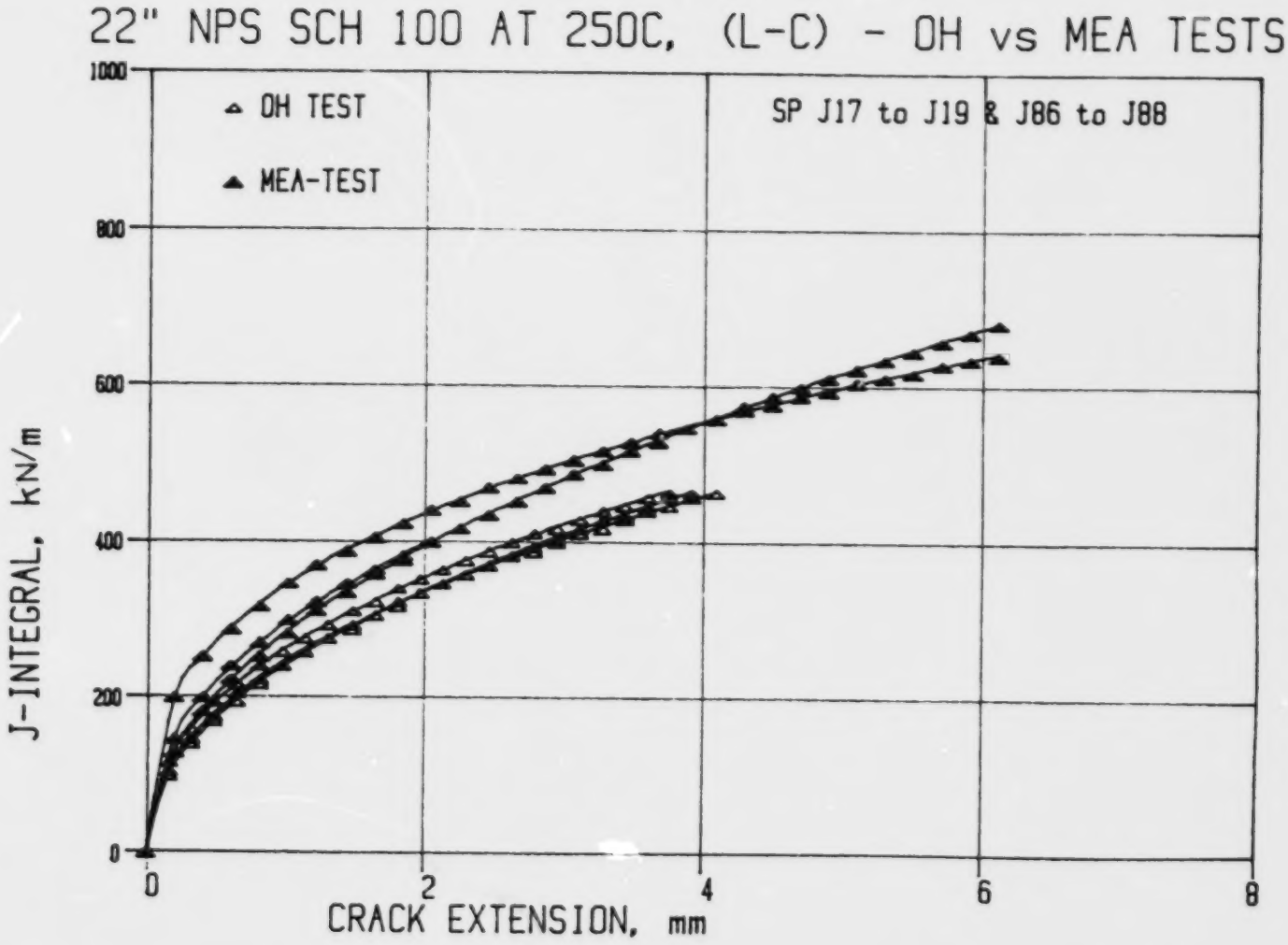

FIGURE 2

COMPARISON OF J-RESISTANCE CURVES BETWEEN OH AND MEA TESTS

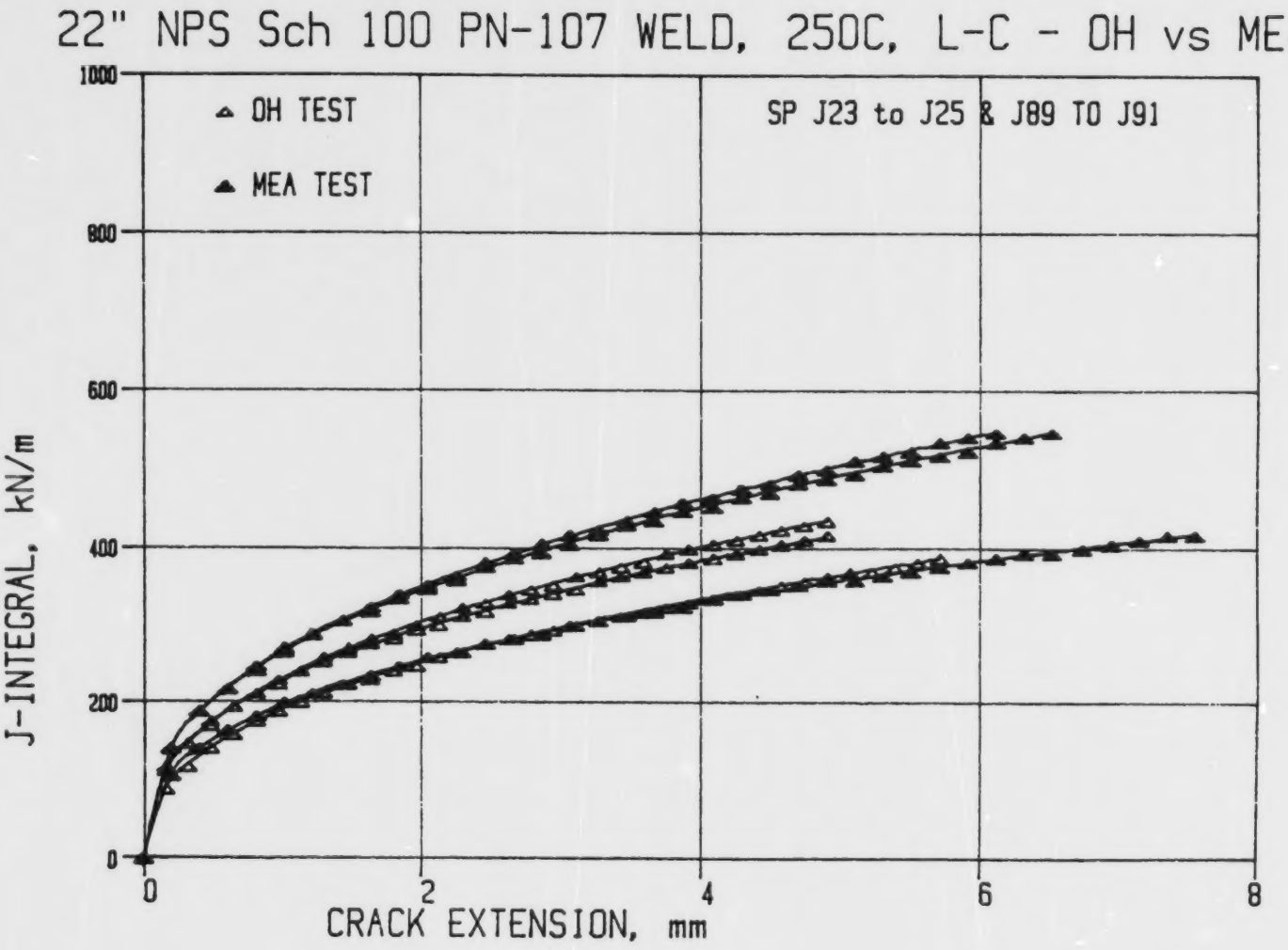

FIGURE 3

COMPARISON OF J-RESISTANCE CURVES BETWEEN OH AND MEA TESTS

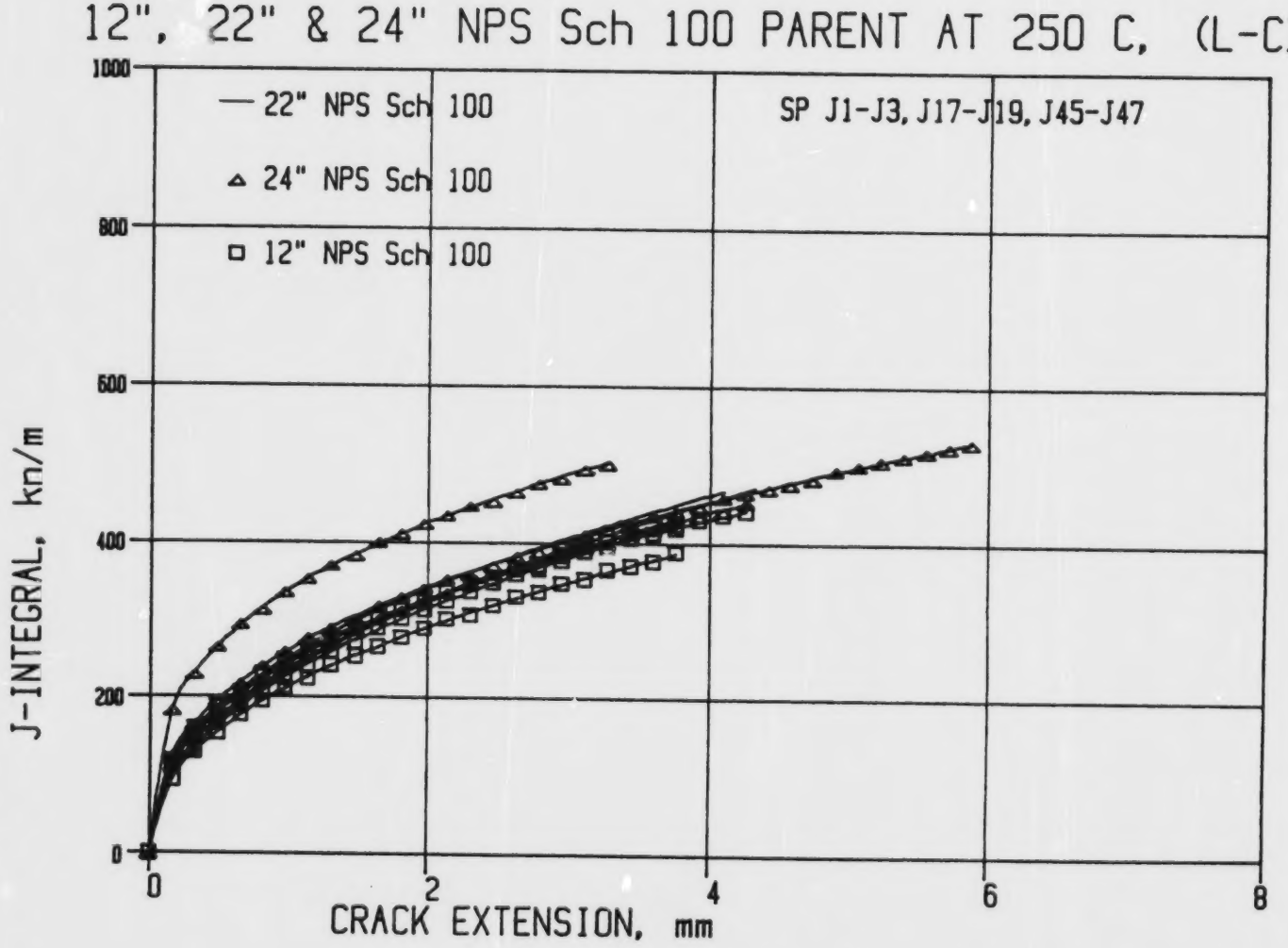

FIGURE 4

J-RESISTANCE CURVES FOR THREE PIPE SIZES

APPENDIX A

Final Report from MEA

ELASTIC-PLASTIC FRACTURE TOUGHNESS (J-INTEGRAL) CHARACTERIZATION FOR SA 106-B SCHEDULE B PIPE

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1. BACKGROUND

This report describes the results and test procedures used in characterizing the elastic-plastic fracture toughness (J-integral) behavior of a section of SA 106-B Schedule 100 pipe and two welded pipe coupons. The Ontario Hydro material designation for this material is N5 for the pipe section and C5 and C8 for the welded coupons. Three compact toughness (CT) specimens were machined from the N5 material, two from the C5 and one from the C8 material. The specimens were fatigue precracked and then side grooved. Machining drawings, material cutting diagrams, and precracking data sheets are located in Appendix A to this report. All specimens were tested at 250°C (482°F) and had an orientation corresponding to LC from the American Society for Testing and Materials (ASTM) Standard E 399-83 (Ref. 1). In other words, crack extension was in the circumferential direction of the pipe. Testing was conducted in accordance with ASTM Standard E 813 using a 20-kip MTS servohydraulic test machine and the single-specimen compliance (SSC) methodology. This technique provides a method to determine specimen crack extension by means of small unloadings (~ 10 to 15% of maximum load) at regular intervals during specimen testing. Because these unload/reload segments are conducted under elastic conditions, even when the specimen has undergone extensive plastic deformation, the change in crack length from one unloading to the next can be inferred through a change in the compliance $(EB\delta/P)$ where E is Young's modulus, B is the specimen thickness, and P and δ are the load and load-line deflection, respectively. The compact toughness specimens of 25.4-mm (1-in.) thickness (1T-CT) used for this study are of relatively large size and provide sufficient mechanical constraint to measure fairly high elastic-plastic fracture toughness levels. For example, the ASTM Standard E 813-83 (Ref. 2) criterion of $B_{net}, b > 25\ J_{Ic}/\sigma_f$ will permit measurements of J_{Ic}, the elastic-plastic fracture toughness at initiation of crack growth, to ~ 300 kJ/m^2 (1700 in.-lb/$in.^2$) for materials of the type studied here. B_{net}, b, and σ_f are the net specimen thickness, the unbroken ligament, and the flow stress, respectively.

J-integral values were determined at each unloading using three formulations of the J integral: J_M, J_D, and the newly proposed ASTM E 813 formulation J_*. The modified J-integral (J_M) calculation procedure is given in Reference 3, and that for J_D is given in Reference 2. The proposed E 813 formulation is as follows:

$$J_* = J_{el} + J_{pl}$$

$$J_{*,i} = K_i^2 \, (1 - \nu^2) \, / \, E + J_{pl,i} \qquad (1)$$

where from ASTM E 399:

$$K_i = P_i \, f(a_o/W) \, / \, (B \, B_N \, W)^{0.5}$$

and

$$J_{pl,i} = \eta A_{pl,i} / (B_N b_i)$$

where $A_{pl,i}$ = the plastic area under the load vs. deflection curve and $\eta = 2 + 0.522\ b_o/W$.

All three formulations of the J integral incorporate corrections for the tension component of specimen loading. A separate correction for specimen rotation was also applied (Ref. 4).

A typical R curve produced with the SSC technique is illustrated in Fig. 1. The format is in accordance with that of the current version of ASTM Standard E 813: initiation fracture toughness is defined by the intersection of a linear regression fit to the data between exclusion lines and the blunting line. However, the R curve in the region between the 0.15-mm and 1.5-mm exclusion lines is more correctly described in terms of a power law, $J = C\ a^n$, where C and n are constants chosen to optimize the curve fit. Proposed changes to ASTM Standard E 813 recognize the nonlinear nature of the R curve and define J_{Ic} as the intersection of a power-law curve fit with an exclusion line drawn parallel to the blunting line but offset by 0.2 mm, a technique analogous to the 0.2% offset tensile yield methodology.

In this study, J_{Ic} was determined at both the intersection of the linear curve fit with the blunting and the intersection of the power-law curve fit with the 0.15-mm offset exclusion line (i.e., the MEA procedure) for all three J-integral formulations. In addition, J_{Ic} was determined at the intersection of the power-law curve fit and the 0.2-mm exclusion line for the J_* data.

This study was conducted with specimens having 20% side grooves. The crack-front extension in a non-side-grooved CT specimen normally exhibits a severely tunneled shape which results from the lack of mechanical constraint at the free surfaces. The lack of mechanical constraint permits plastic deformation in these regions at the expense of crack extension. Just the opposite is true in a more highly constrained region (for example, the specimen midthickness). Currently, there is disagreement as to whether the tunneling is representative of the crack-front behavior in a large structure. Nevertheless, this phenomenon does result in a three-dimensional effect which may not be properly accounted for by the two-dimensional form of the J integral. It has been shown that side grooving by 20% total depth will eliminate the tunneling in CT specimens having thicknesses of 12 to 100 mm. In addition, the R curves produced with a straight crack-front extension exhibit slopes (dJ/da) lower than those associated with tunneled crack extension. Side grooving also appears to produce a slightly lower (more conservative) value for crack initiation toughness. Thus, it is possible that side-grooved specimens may more accurately represent the behavior of thick-section materials.

2. ELASTIC-PLASTIC FRACTURE TOUGHNESS RESULTS

Initiation fracture toughness results are summarized in Table 1. Specimen numbers were established by Ontario Hydro. The J-R curves for each of the J formulations are illustrated graphically in Figs. 2, 3, and 4 in terms of J vs. Δa and in terms of J vs. tearing modulus (T) in Figs. 5, 6, and 7. It is clear from these figures that the weld material is of a somewhat lower toughness than that of the base material.

Values of the tearing modulus obtained for the various J formulations and curve-fitting techniques are summarized in Table 2. Note that the T values for the weld also are somewhat lower for the weld corresponding to that of the J_{Ic} toughness trend. The specimen taken from weld coupon C8 exhibited the lowest toughness. It also should be noted that weld specimen J89 exhibited what appears to be ductile pop-in behavior from post-test examination of the fracture surface.

For each specimen tested there are eight supplemental data sheets which can be found in Appendix B. For each J formulation--J_M, J_D, and J_*--two power-law curve fits were made. One to provide a best fit in the vacinity of the intersection with the 1.5-mm exclusion line (abscissa = 2.5 mm) and a second to fit the data further out on the R curve (abscissa = 15 mm). In addition, there is one plot of the overall load vs. load-line deflection and one data sheet for the J_* formulation curve fit to determine the intersection with the 0.2-mm offset exclusion line. This latter data sheet conforms to the changes proposed to ASTM Standard E 813.

Two of the specimen tests may be invalid by current ASTM E 813 criteria because the specimen precrack was nonuniform. ASTM E 813 requires that the precrack be measured at nine equally spaced locations across the fracture surface. The average of these measurements must be at least 5% of the total crack size and not less than 1.27 mm. Since 1T-CT specimens were tested, the precrack must be 1.27 mm long. However, one of the nine measurements near the specimen centerline on each specimen was slightly less than 1.27 mm. Thus, for these two specimens, one might consider the data invalid even though the nine-point average for each precrack meets the E 813 criteria. Since both specimens were taken from the same weld material (C5), it is possible that the cause of this problem was residual stresses in the material.

In this study, MEA proposed to continue all tests to a crack extension equal to half of the initial unbroken ligament. However, specimen test J88 was terminated early due to failure of the load-line clip gage. Nevertheless, this test is valid by E 813 criteria.

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2. American Society for Testing and Materials, Metals -- Mechanical Testing, Vol. 3.01, E 813-81, 1985.

3. H. A. Ernst, "Material Resistance and Instability Beyond J-Controlled Crack Growth," Elastic-Plastic Fracture: Second Symposium, Vol. I: Inelastic Crack Analysis, ASTM STP 803, 1983.

4. F. J. Loss, B. H. Menke, and R. A. Gray, "Development of J-R Curve Procedures," in The NRL-EPRI Research Program (RP886-2), Evaluation and Prediction of Neutron Embrittlement in Reactor Pressure Vessel Materials, Annual Report for CY 1978, NRL Report 8327, Naval Research Laboratory, Aug. 30, 1979, pp. 30-57.

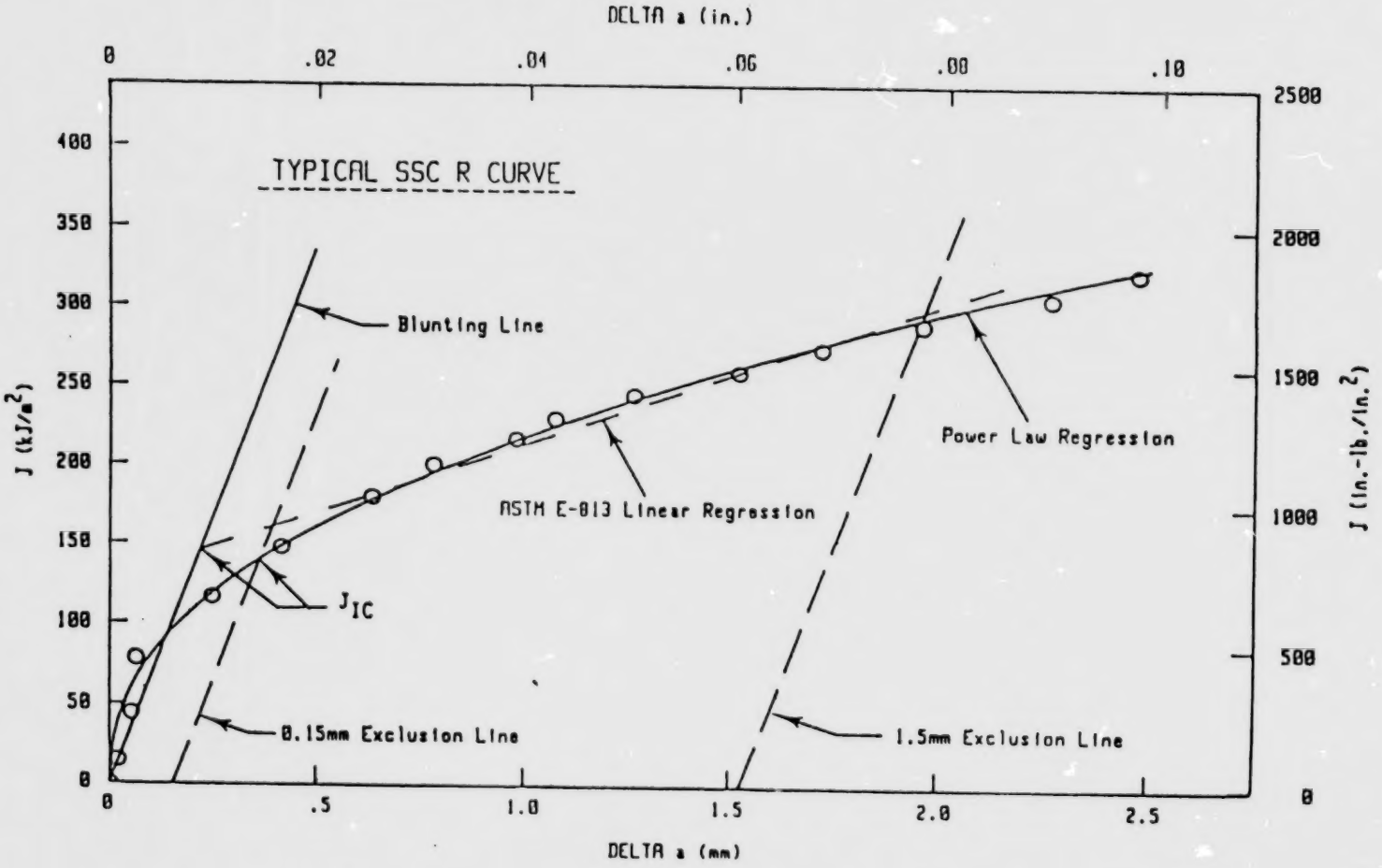


Fig. 1 Power-law R curve generated with the SSC approach. An alternate definition of J_{Ic} is compared to that of the current ASTM procedure (linear regression). The proposed ASTM E 813 J_{Ic} point is the power-law regression intersection with an exclusion line offset by 0.2 mm.

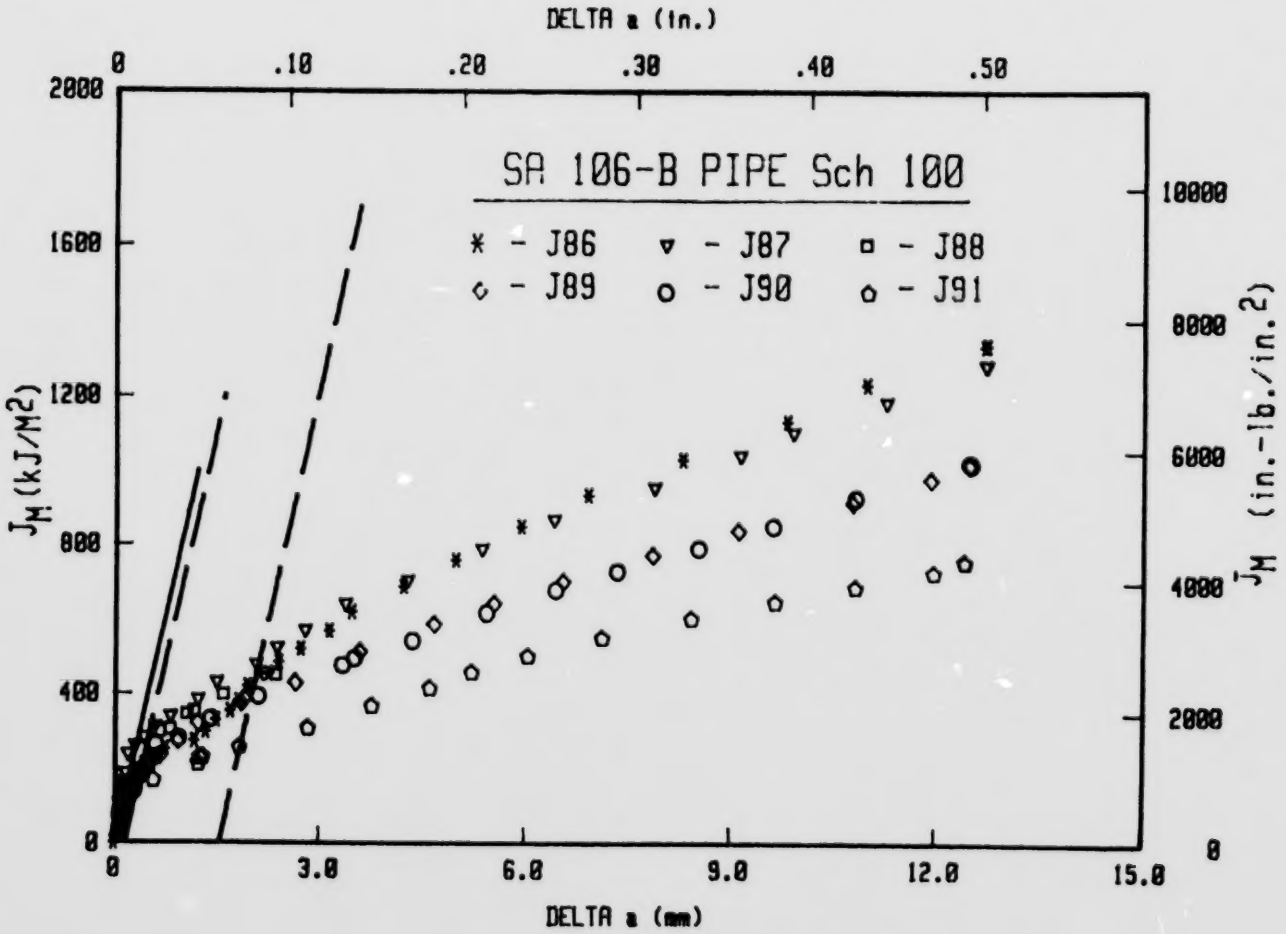


Fig. 2 Comparison of the J-R curves from the six tests using the modified J-integral formulation.

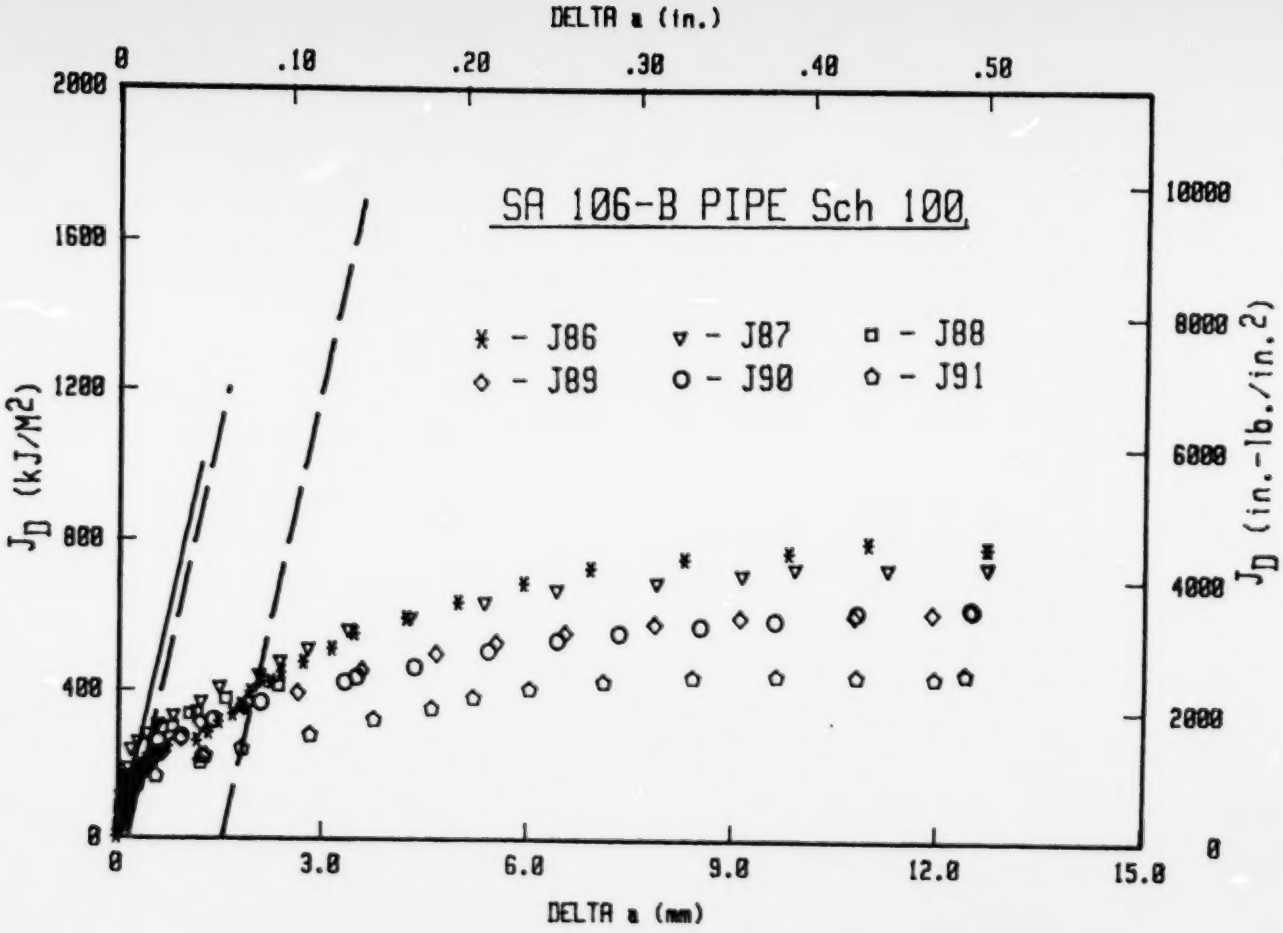


Fig. 3 Comparison of the J-R curves from the six tests using the deformation J-integral formulation.

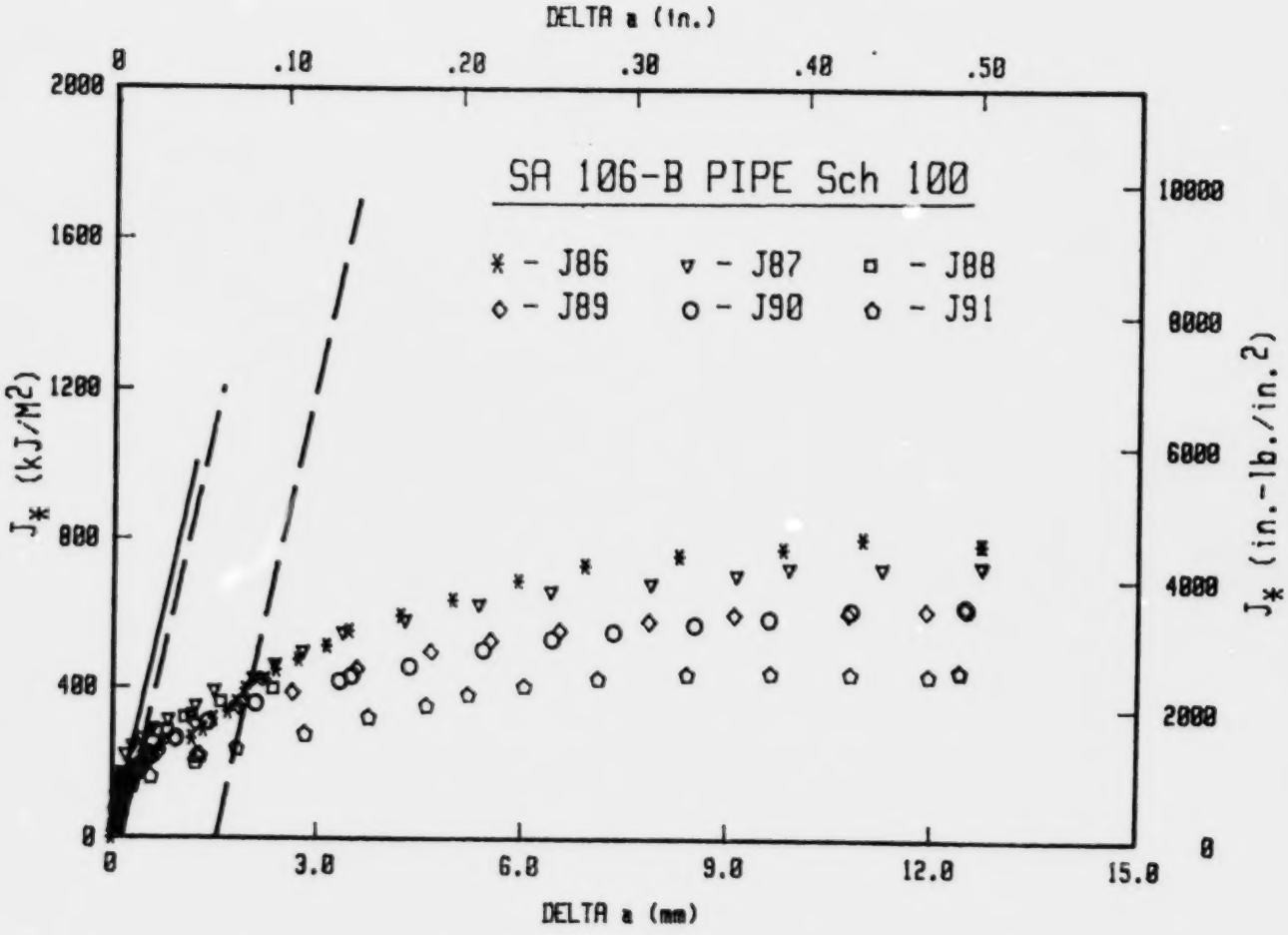


Fig. 4 Comparison of the J-R curves from the six tests using the proposed E 813 J-integral formulation.

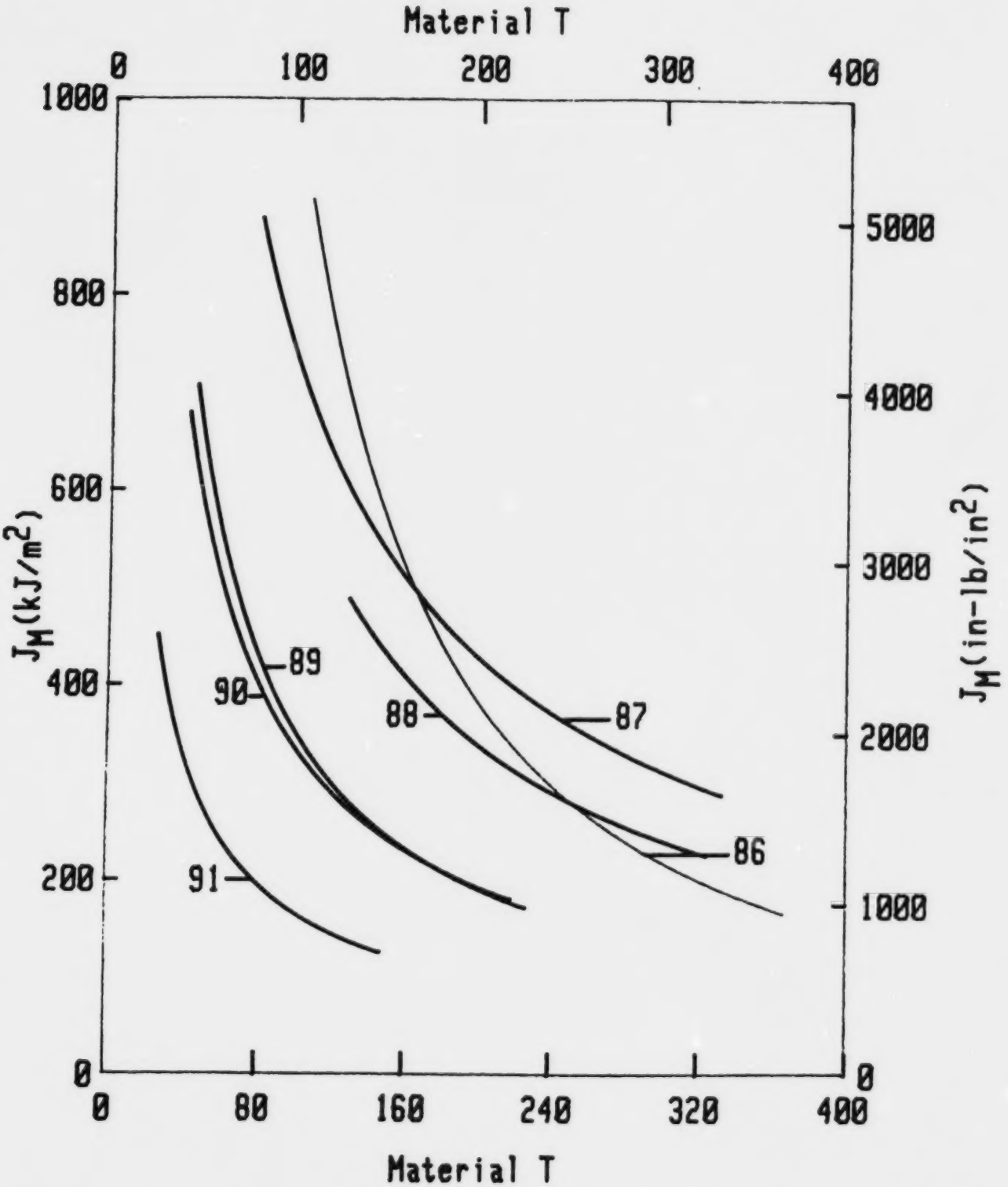


Fig. 5 Comparison of the J-R curves from the six tests in terms of J and the material tearing modulus (T) using the modified J integral formulation. Curves begin at the lower right approximately at J_{Ic}.

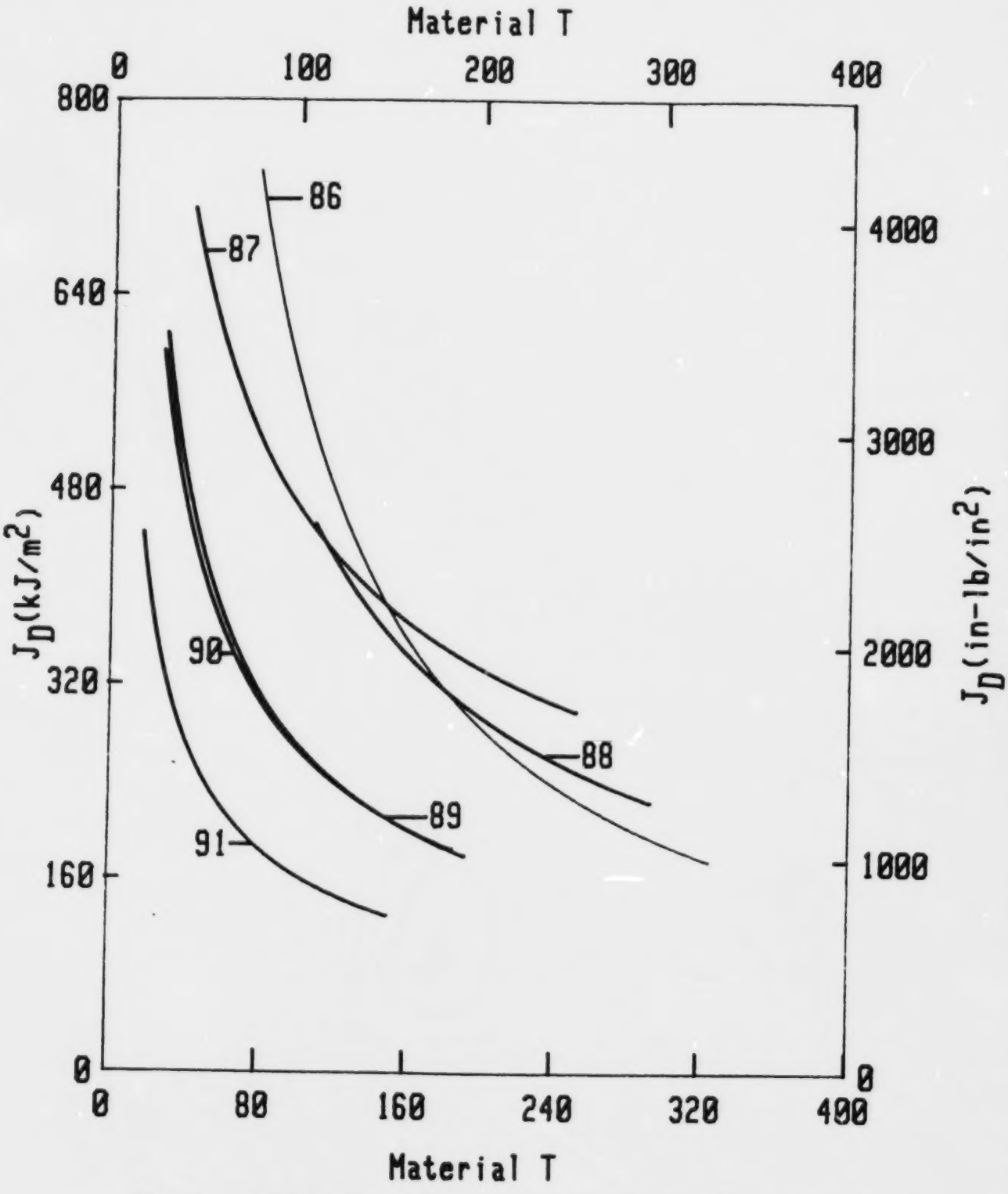


Fig. 6 Comparison of the J-R curves from the six tests in terms of J and the material tearing modulus (T) using the deformation J integral formulation. Curves begin at the lower right approximately at J_{Ic}.

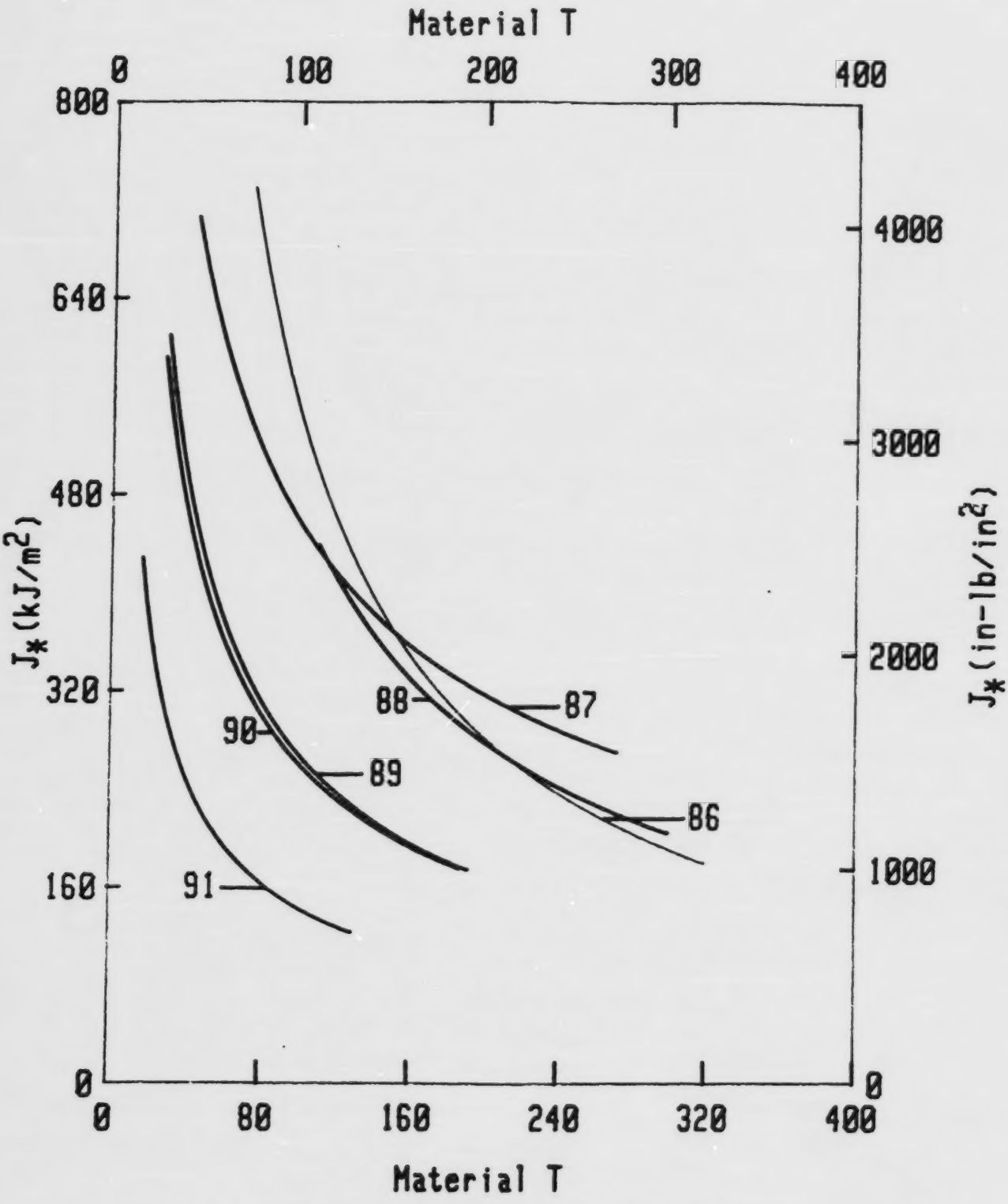


Fig. 7 Comparison of the J-R curves from the six tests in terms of J and the material tearing modulus (T) using the proposed E 813 J integral formulation. Curves begin at the lower right approximately at J_{Ic}.

Table 1 J-Integral Fracture Toughness Data Summary for SA 106 Sch. 100 Pipe and Weld[a]

Specimen Number	$(a/w)_i$[b]	a_m[c]	$a_p - a_m$[d]	J_{Ic}							ASTM E 813 Validity	Flow Stress
				Power Law (0.15 mm)[e]			Current ASTM E 813[f]			Proposed[g]		
				J_M	J_D	J_*	J_M	J_D	J_*	J_*		
		(mm)	(mm)	(kJ/m^2)	(kJ/m^2)	(kJ/m^2)	(kJ/m^2)	(kJ/m^2)	(kJ/m^2)	(kJ/m^2)		(MPa)
J86(N5)	0.512	13.08	-0.33	194.9	197.4	195.1	178.4	178.1	181.5	204.1	Valid	364.6
J87(N5)	0.520	13.48	-0.72	306.5	296.8	275.9	292.4	290.6	272.2	283.7	Valid	364.6
J88(N5)[h]	0.525	2.29	+0.13	216.3	209.3	196.0	228.3	228.9	188.7	209.8	Valid	364.6
J89(C5)[i]	0.501	12.73	-0.23	176.6	176.0	171.5	165.1	167.2	162.7	183.4	——[i]	448.0
J90(C5)[i]	0.507	12.89	-0.40	185.0	181.8	174.5	176.4	177.5	170.2	186.4	——[i]	448.0
J91(C8)	0.537	12.58	-0.16	130.2	128.9	124.1	126.7	127.3	122.2	139.5	Valid	448.0

[a] Testing conducted at 250°C, ASTM Standard E 399 specimen orientation LC, side grooved 10% of thickness on each side

[b] Initial a/W

[c] Measured crack extension

[d] Difference between measured and predicted crack extension

[e] J_{Ic} for the three formulations of the J integral determined at the intersection of the power-law regression and 0.15-mm exclusion line

[f] J_{Ic} for the three formulations of the J integral determined at the intersection of linear regression and the blunting line

[g] J_{Ic} determined at the intersection of the power-law regression and the 0.2-mm exclusion line for J_* data

[h] Equipment failure terminated test at Δa = 2.29-mm crack extension, just beyond the second exclusion line

[i] Nonuniform precrack: one of nine measurements is less than the 1.27 mm required by E 813; however, the average is > 1.27 mm

Table 2 Tearing Modulus Summary

Specimen Number	E 813[a]			MEA[b]		
	J_M	J_D	J_*	J_M	J_D	J_*
J86(N5)	181	164	160	170	142	144
J87(N5)	168	137	139	153	146	150
J88(N5)	203	177	208	204	207	183
J89(C5)	125	111	111	117	105	104
J90(C5)	128	116	113	115	105	104
J91(C8)	69	62	63	63	57	58

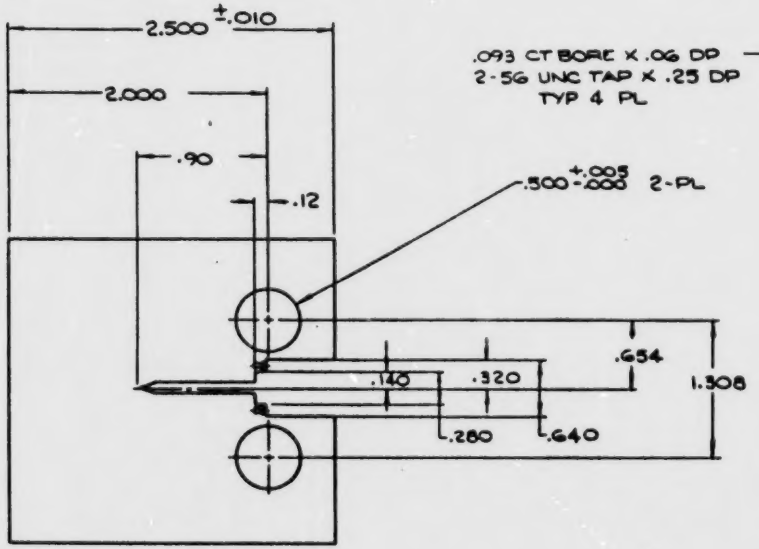
[a] Values tabulated were obtained using the ASTM E 813 procedure

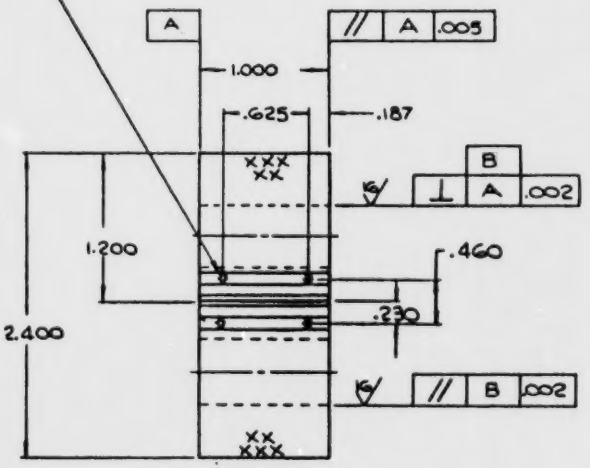
[b] Values tabulated were obtained by fitting a linear least-square regression to the power-law equation between the 0.15-mm and 1.5-mm exclusion lines.

APPENDIX A

PART NO.	DESCRIP.	QTY.

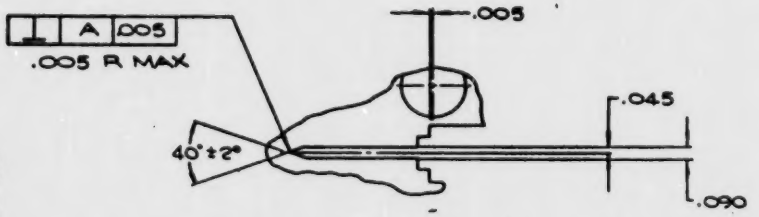
REV	ZONE	ECO	DESCRIPTION	DWN	CHKD	DATE	APVD





NOTES:

1) STAMP SPECIMEN CODE Nº (XX) AND SPECIMEN CONSECUTIVE Nº (XX) TWO PLACES AS SHOWN



DETAIL 'C'

DETACHED LISTS	DWN	CEB	Materials Engineering Associates, Inc. LANHAM, MD 20706
MICROFILMED	ENG	MFG	DO NOT SCALE THIS PRINT
REV	QA	APVD	

SPECIFICATIONS UNLESS OTHERWISE NOTED
DIMENSIONS & TOLERANCES APPLY AFTER FINISH
DEBURR AND BREAK SHARP EDGES
DIMENSIONS ARE IN INCHES

MATERIAL: AS SUPPLIED

FINISH:

TOLERANCES
THREE PLACE ± .005
TWO PLACE ±
ANGLES ±

63 ALL MACHINED SURFACES

TITLE: I.O.T-CT SPECIMEN J MODIFIED

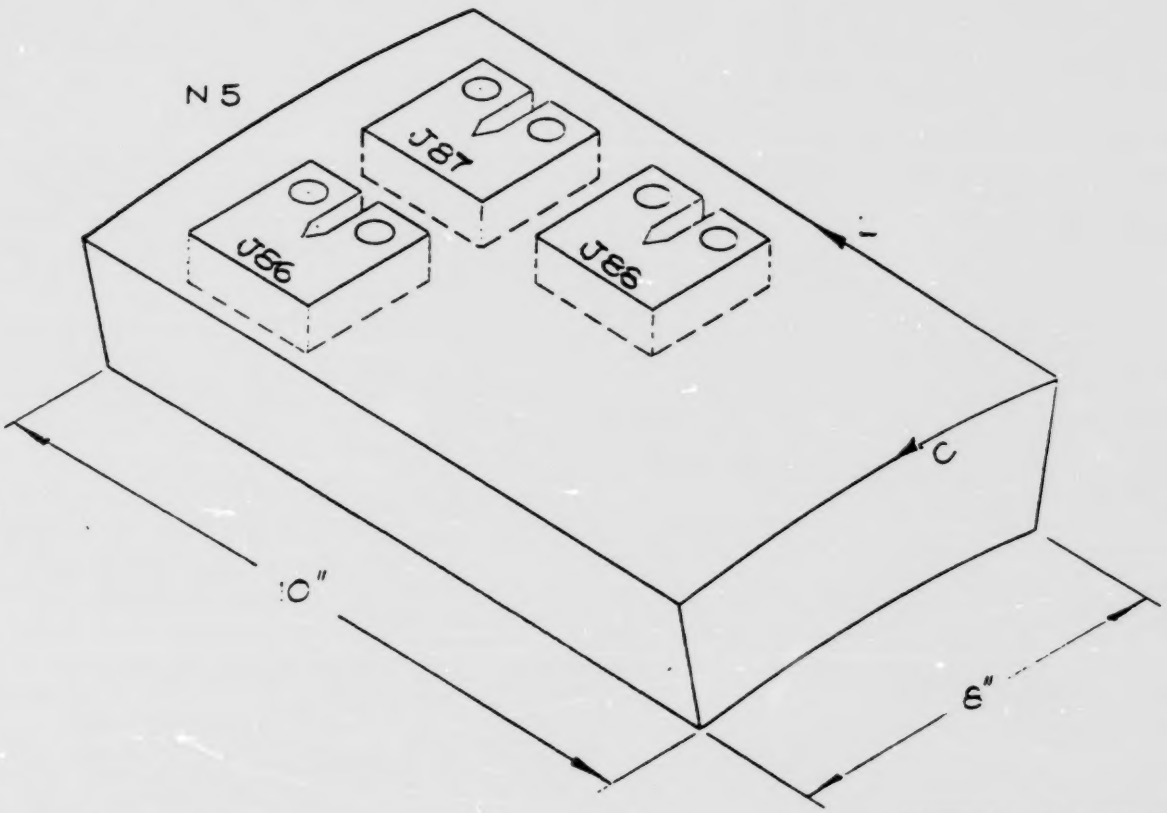
C | DWG NO.: MEA-AO-5000 | REV:

SCALE: NTS | SHEET OF

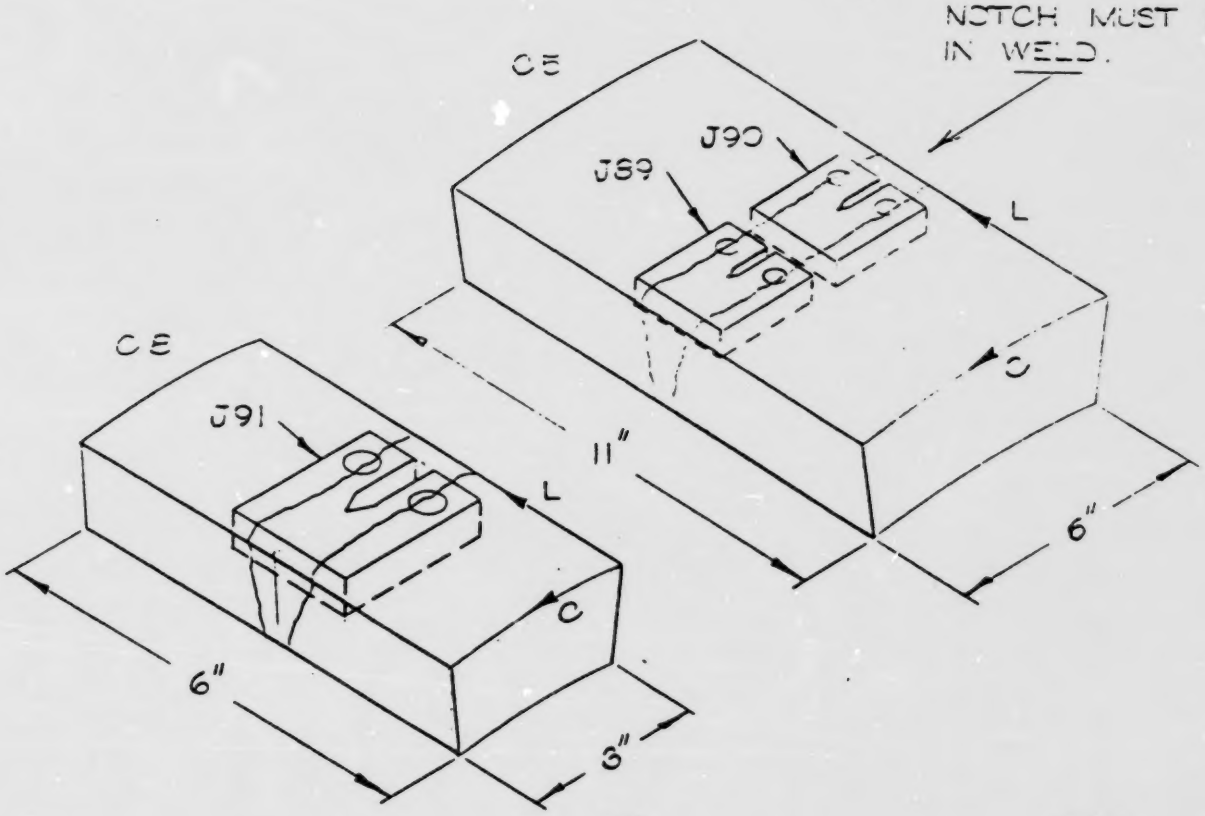
24

87-262

CUTTING DIAGRAM
(PREPARED BY ONTARIO HYDRO)



NOTCH MUST BE IN WELD.



87-262

MATERIALS ENGINEERING ASSOCIATES

PRECRACKING DATA RECORD

JOB No.	P/O No.	SPECIMEN TYPE	SPECIMEN ID No.
468		1T-CT	N5J86

WIDTH	THICKNESS	MACHINED NOTCH LENGTH	FINAL CRACK LENGTH
2	1	.900	1.000

P max	P min	a_r	a_f	N	Comments
2900	290	1.000	1.000	160 000	COMPRESSED TO 2900#

MJL
Operator

3/25/86
Date

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MATERIALS ENGINEERING ASSOCIATES

PRECRACKING DATA RECORD

JOB No.	P/O No.	SPECIMEN TYPE	SPECIMEN ID No.
468		1T-CT	N5J87

WIDTH	THICKNESS	MACHINED NOTCH LENGTH	FINAL CRACK LENGTH
2	1	.900	1.000

P max	P min	a_r	a_f	N	Comments
2900	290	1.000	1.000	170 000	COMPRESSED TO 2900#

87-262

MJL
Operator

3/25/86
Date

MATERIALS ENGINEERING ASSOCIATES			PRECRACKING DATA RECORD
JOB No. 468	P/O No.	SPECIMEN TYPE 1T-CT	SPECIMEN ID No. N5 J88
WIDTH 2	THICKNESS 1	MACHINED NOTCH LENGTH .900	FINAL CRACK LENGTH 1.000

P max	P min	a_r	a_f	N	Comments
2900	290	1.000	1.000	130 000	COMPRESSED TO 2900#

MJL
Operator

3/25/86
Date

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.204 86

MATERIALS ENGINEERING ASSOCIATES — PRECRACKING DATA RECORD

JOB No.	P/O No.	SPECIMEN TYPE	SPECIMEN ID No.
468		1T-CT	C5J89

WIDTH	THICKNESS	MACHINED NOTCH LENGTH	FINAL CRACK LENGTH
2	1	.900	1.000

P max	P min	a_r	a_f	N	Comments
2900	290	1.000	1.000	370 000	COMPRESSED TO .2900"

MJL
Operator

3/26/86
Date

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MATERIALS ENGINEERING ASSOCIATES

PRECRACKING DATA RECORD

JOB No.	P/O No.	SPECIMEN TYPE	SPECIMEN ID No.
468		1T-CT	C5J90

WIDTH	THICKNESS	MACHINED NOTCH LENGTH	FINAL CRACK LENGTH
2	1	.900	1.000

P max	P min	a_r	a_f	N	Comments
2900	290	1.005	.995	340000	COMPRESSED TO 2900#

MJL
Operator

3/26/86
Date

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MATERIALS ENGINEERING ASSOCIATES

PRECRACKING DATA RECORD

JOB No.	P/O No.	SPECIMEN TYPE	SPECIMEN ID No.
468		1T-CT	C8591

WIDTH	THICKNESS	MACHINED NOTCH LENGTH	FINAL CRACK LENGTH
2	1	.900	1.000

P max	P min	a_r	a_f	N	Comments
2900	290	.900	.900	0-120,000	COMPRESSED TO 2900#
2900	290	.975	.900	140,000	Shims added, long side clamped
2900	290	.990	.950	310,000	
2900	290	1.015	.995	395,000	

MJL
Operator

3/27/86
Date

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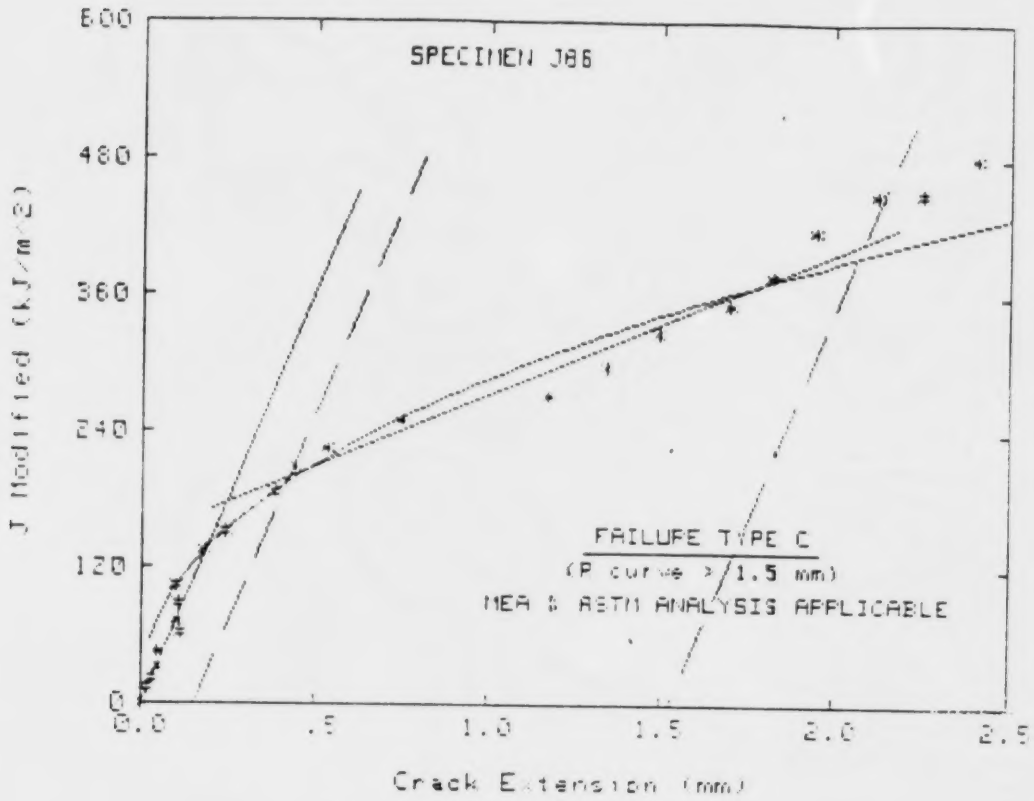
APPENDIX B



TEST SPECIMEN DATA

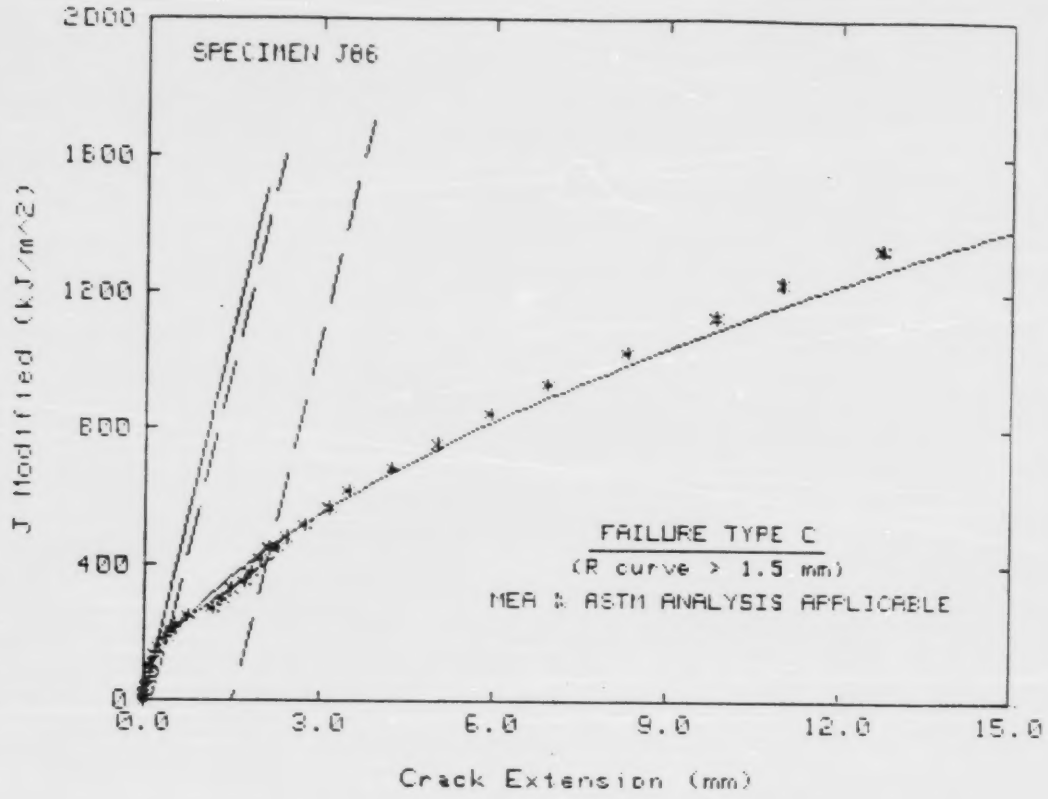
Material Type	= SA-106B (PIPE #HE)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.03 mm	Init a/W = .511
Final Crack Length	= 39.11 mm	Final a/W = .769
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a)^N

Jic	= 194.9 kJ/m^2
Kjc	= 193.9 MPa sqrt(m)
J (@J T=8.8)	= 922.9 kJ/m^2
Exponent N	= .4429
Coefficient C	= 286.3 kJ/m^2
T (average)	= 170

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 178.4 kJ/m^2	
Kjc	= 185.5 MPa sqrt(m)	
Slope M	= 124416.2 kJ/m^3	
Intercept B	= 148 kJ/m^2	
T (ASTM)	= 181	
Validity (Jic)	= VALID	
Validity (R-curve)	= VALID	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.48 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.75 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 3	Points Right = 0



TEST SPECIMEN DATA

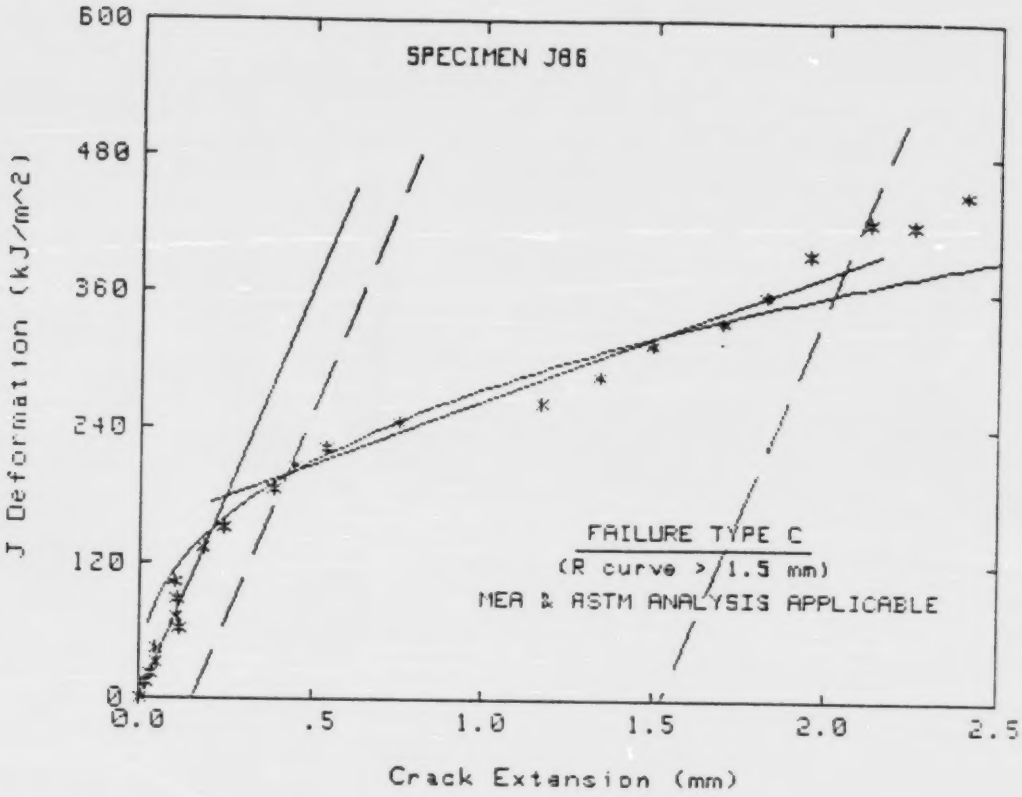
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.03 mm	Init a/W = .512
Final Crack Length	= 39.11 mm	Final a/W = .769
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value

POWER LAW DATA J = C (Delta a) ^ N

J (@J T=8.8)	= 922.9 kJ/m^2
Jic	= 165.5 kJ/m^2
Kjc	= 178.7 MPa √m
Exponent N	= .5795
Coefficient C	= 290.2 kJ/m^2
T (average)	= 229

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 178.4 kJ/m^2	
Kjc	= 185.5 MPa √m	
Slope M	= 124416.2 kJ/m^3	
Intercept B	= 148 kJ/m^2	
T (ASTM)	= 181	
Validity (Jic)	= VALID	
Validity (R-curve)	= VALID	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.48 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.75 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 12



TEST SPECIMEN DATA

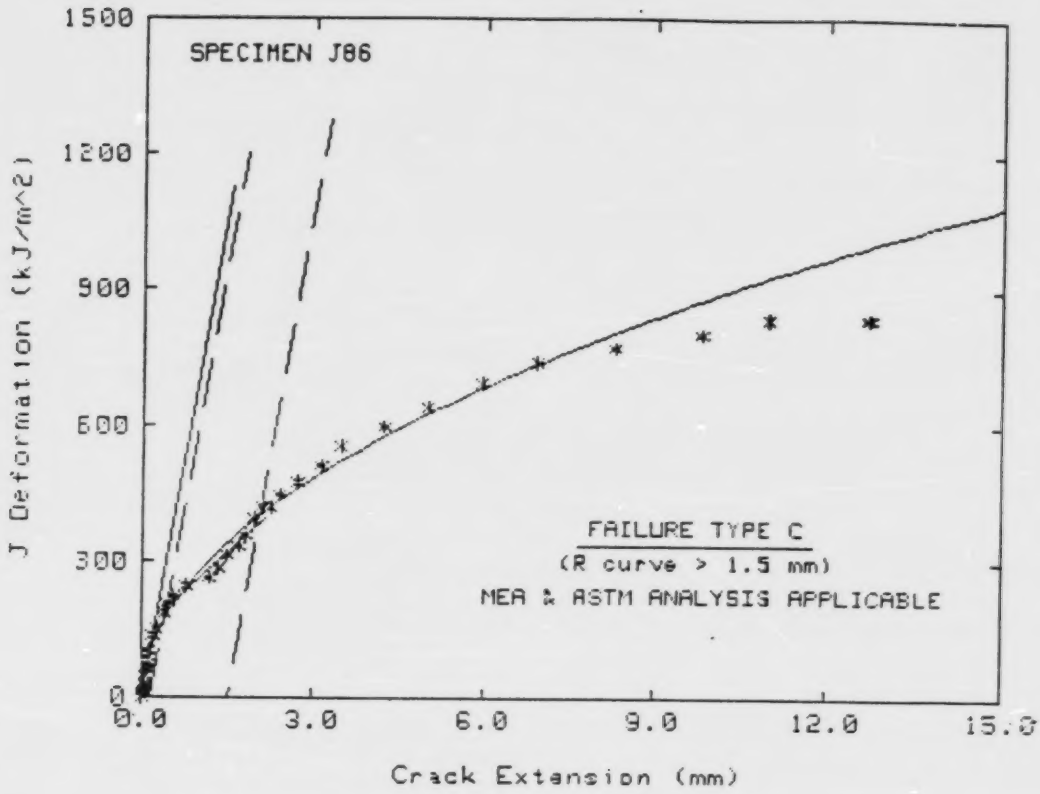
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.03 mm	Init a/W = .512
Final Crack Length	= 39.11 mm	Final a/W = .769
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 197.4 kJ/m^2
Kjc	= 195.1 MPa √m
J (@J/T=8.8)	= 706.9 kJ/m^2
Exponent N	= .3835
Coefficient C	= 274.5 kJ/m^2
T (average)	= 142

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 178.1 kJ/m^2	
Kjc	= 185.4 MPa √m	
Slope M	= 112744.7 kJ/m^3	
Intercept B	= 150.6 kJ/m^2	
T (ASTM)	= 164	
Validity (Jic)	= VALID	
Validity (R-curve)	= VALID	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.48 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.75 mm	
Poisson's Ratio (υ)	= 0	
Points Left	= 1	Points Right = 0



TEST SPECIMEN DATA

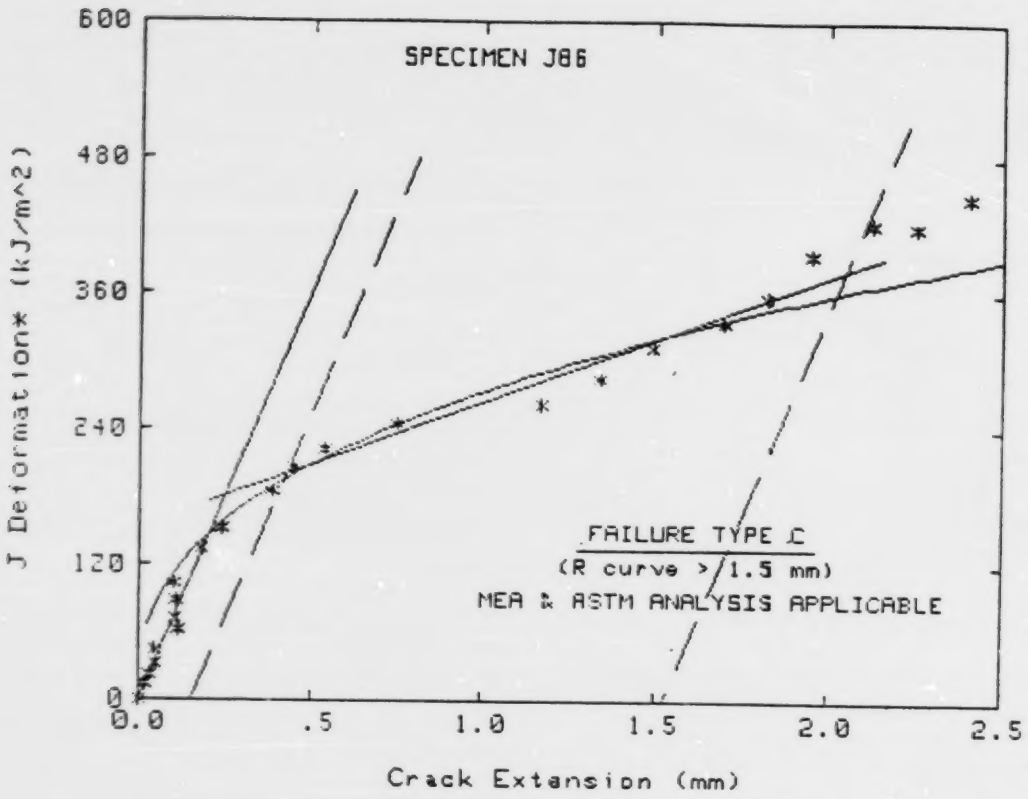
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.03 mm	Init a/W = .512
Final Crack Length	= 39.11 mm	Final a/W = .769
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 706.9 kJ/m^2
Jic	= 174.7 kJ/m^2
Kjc	= 183.6 MPa √m
Exponent N	= .5014
Coefficient C	= 279.4 kJ/m^2
T (average)	= 191

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 178.1 kJ/m^2	
Kjc	= 185.4 MPa √m	
Slope M	= 112744.7 kJ/m^3	
Intercept B	= 150.6 kJ/m^2	
T (ASTM)	= 164	
Validity (Jic)	= VALID	
Validity (R-curve)	= VALID	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.48 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.75 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 8



TEST SPECIMEN DATA

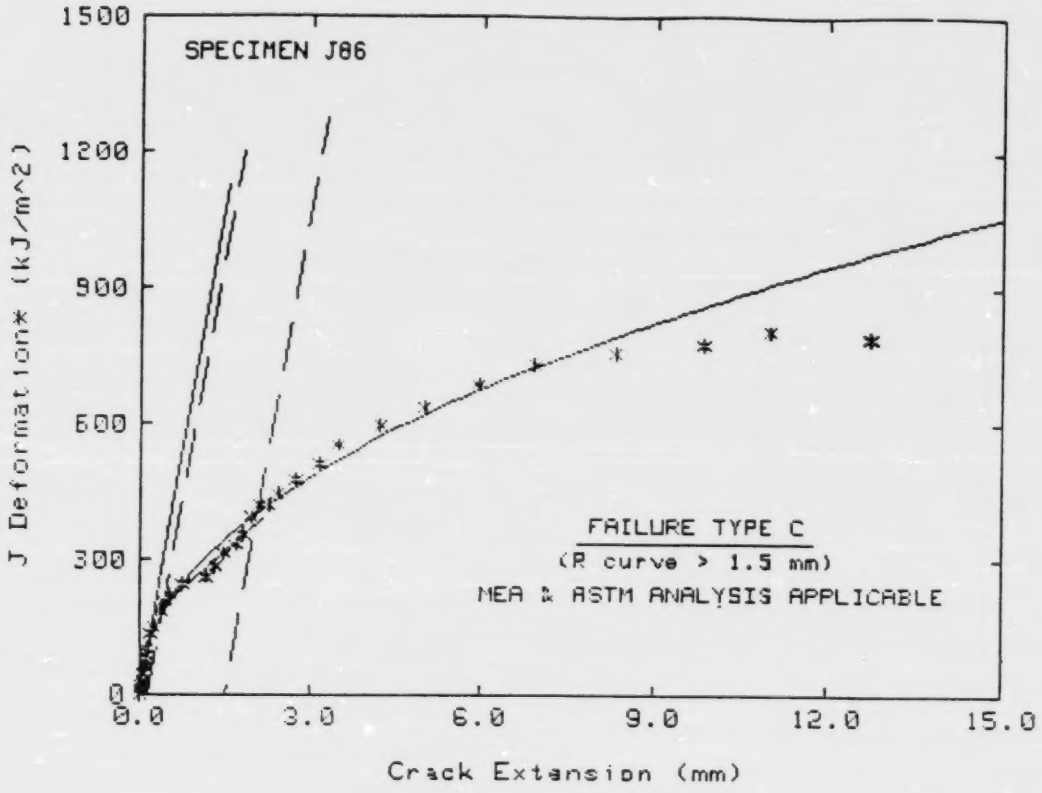
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.03 mm	Init a/W = .512
Final Crack Length	= 39.11 mm	Final a/W = .769
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 195.1 kJ/m^2
Kjc	= 194 MPa √m
J (@J/T=8.8)	= 687.7 kJ/m^2
Exponent N	= .3893
Coefficient C	= 273.5 kJ/m^2
T (average)	= 144

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 181.5 kJ/m^2	
Kjc	= 187.1 MPa √m	
Slope M	= 110215.7 kJ/m^3	
Intercept B	= 154 kJ/m^2	
T (ASTM)	= 160	
Validity (Jic)	= VALID	
Validity (R-curve)	= VALID	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.48 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.75 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 0



TEST SPECIMEN DATA

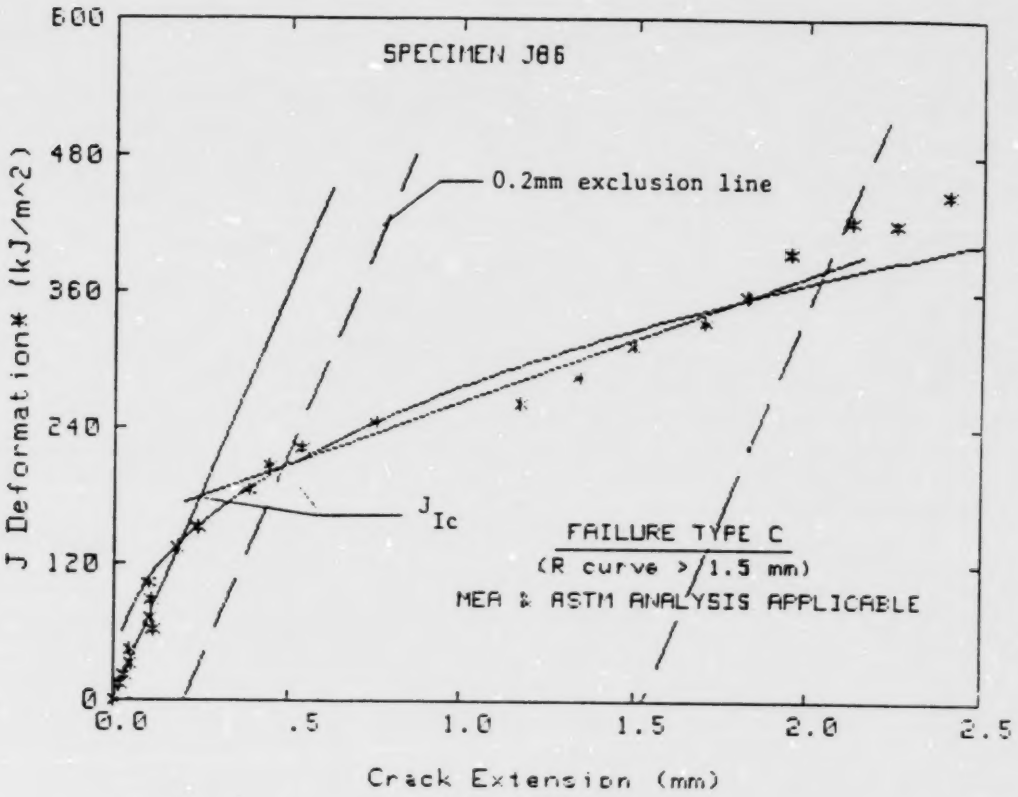
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.03 mm	Init a/W = .512
Final Crack Length	= 39.11 mm	Final a/W = .769
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 687.7 kJ/m^2
Jic	= 179.7 kJ/m^2
Kjc	= 186.2 MPa √m
Exponent N	= .4888
Coefficient C	= 281.6 kJ/m^2
T (average)	= 187

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 181.5 kJ/m^2	
Kjc	= 187.1 MPa √m	
Slope M	= 110215.7 kJ/m^3	
Intercept B	= 154 kJ/m^2	
T (ASTM)	= 160	
Validity (Jic)	= VALID	
Validity (R-curve)	= VALID	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.48 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.75 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 8



TEST SPECIMEN DATA

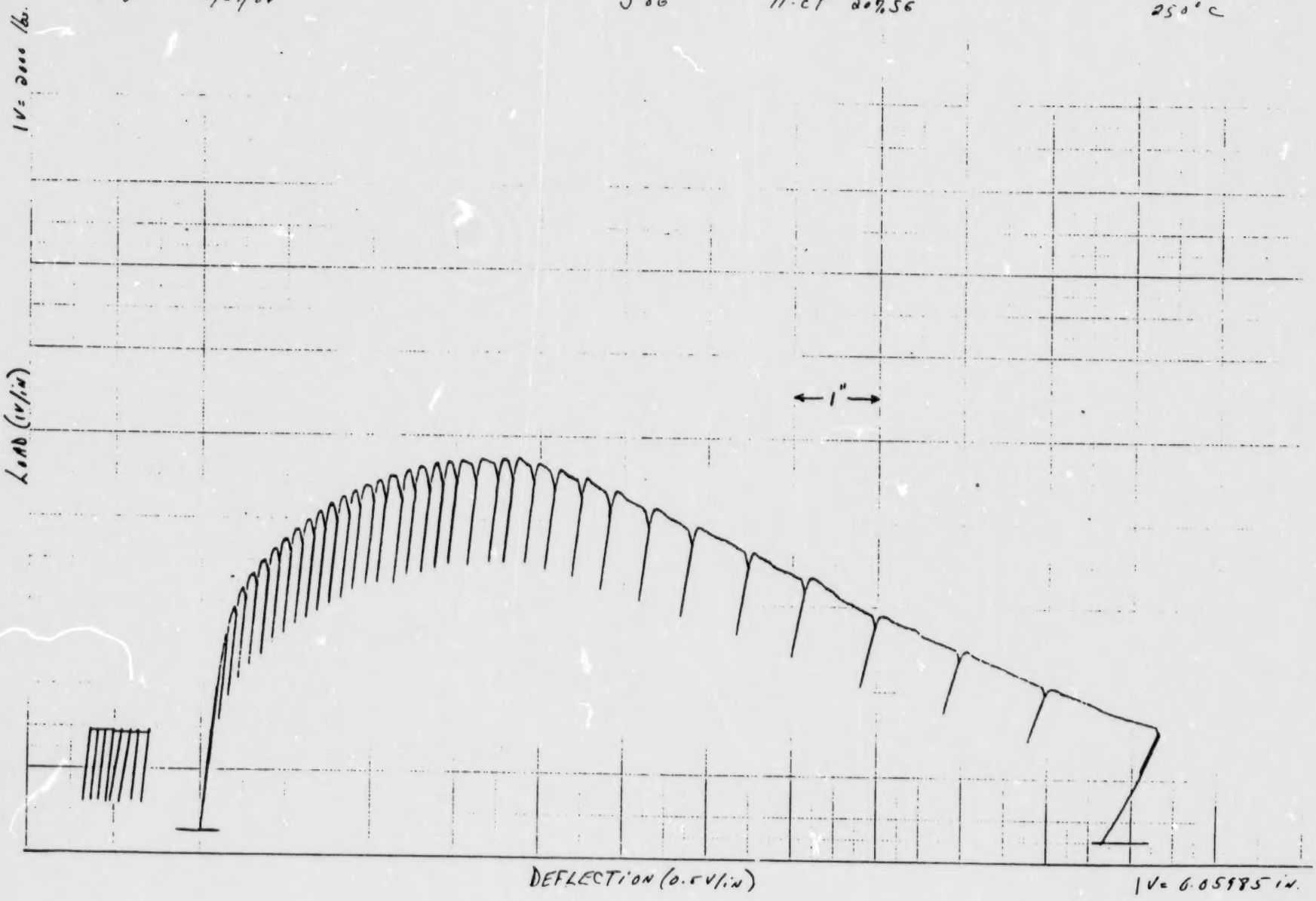
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Init crack length	= 26.03 mm	Init a/W = .512
Final crack length	= 39.11 mm	Final a/W = .769
Flow stress	= 364.6 MPa	
Youngs modulus	= 192900 MPa	(Estimated Value)

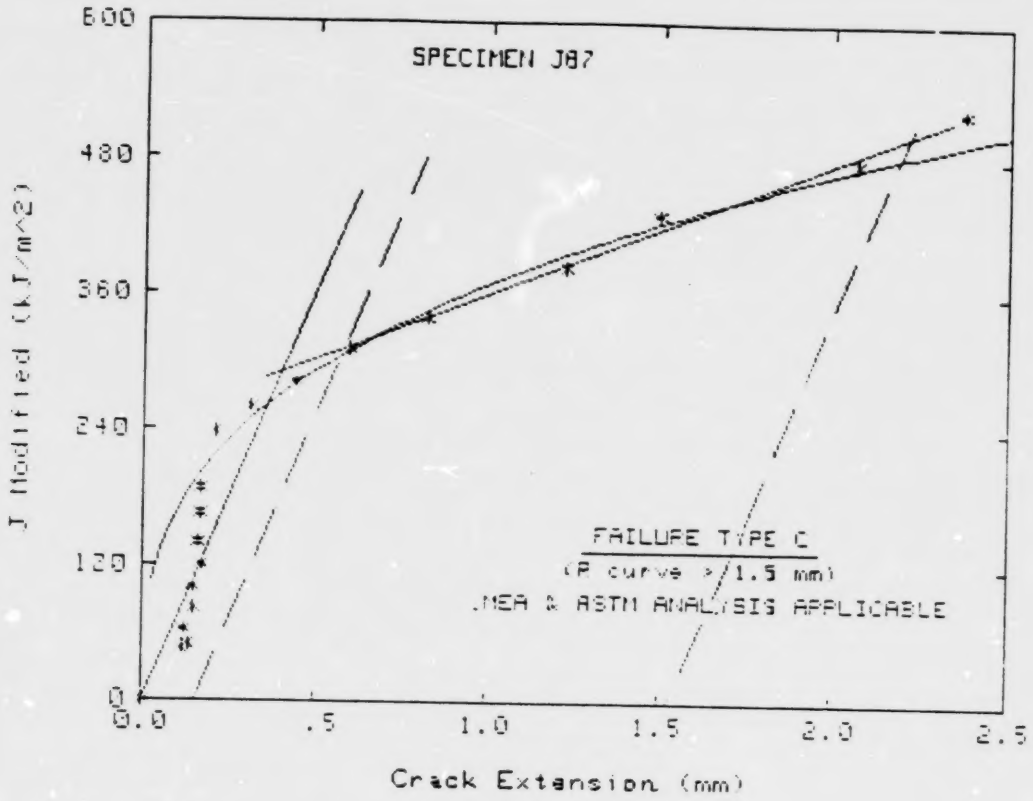
POWER LAW DATA J = C (Delta a) ^ N

Jic	= 204.1 kJ/m^2
Kjc	= 195.4 MPa √m
J (@J/T=8.8)	= 702.2 kJ/m^2
Exponent N	= .4141
Coefficient C	= 276.6 kJ/m^2
T (average)	= 151

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 178.1 kJ/m^2	
Kjc	= 185.3 MPa √m	
Slope M	= 112369.5 kJ/m^3	
Intercept B	= 150.6 kJ/m^2	
T (ASTM)	= 163	
Validity (Jic)	= VALID	
Validity (R-curve)	= VALID	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.48 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.75 mm	
Poisson's Ratio (v)	= 0	


LKF 3/27/86
J86
IT·CT 20.56
250°C
1V = 2000 lb.
LOAD (1V/in)
40
87-262
←1"→
DEFLECTION (0.5V/in)
1V = 0.05985 in.



TEST SPECIMEN DATA

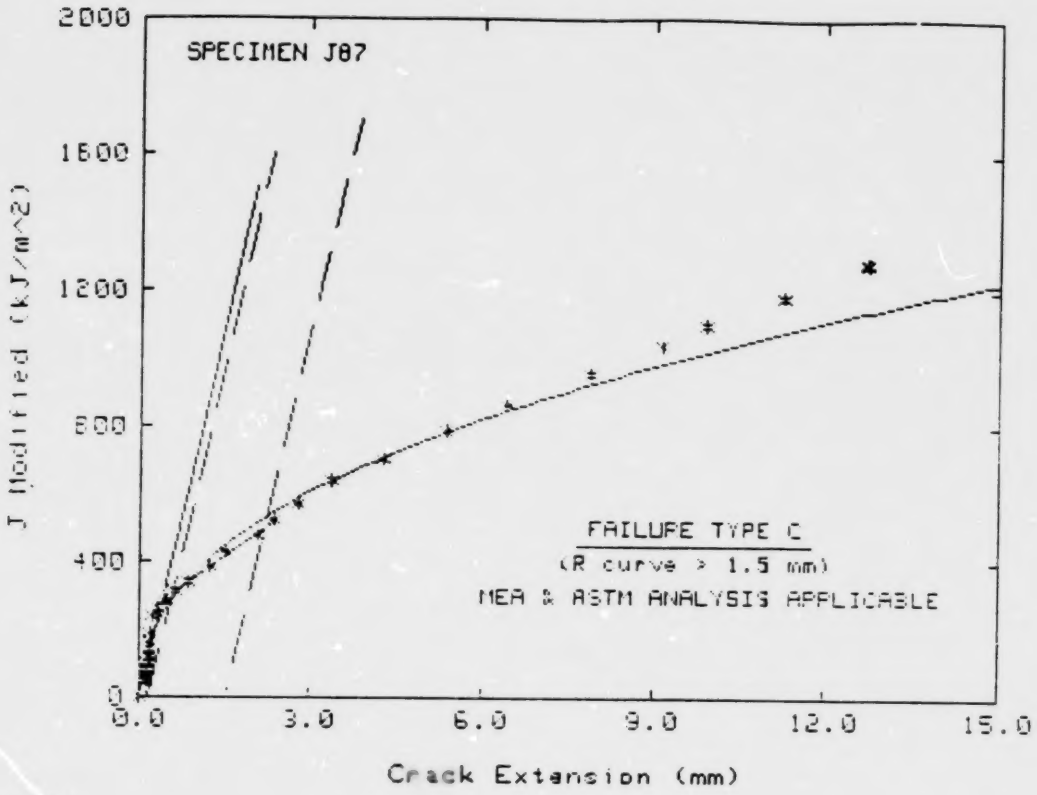
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.43 mm	Init a/W = .52
Final Crack Length	= 39.91 mm	Final a/W = .785
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 306.5 kJ/m^2
Kjc	= 243.2 MPa √m
J (@J/T=8.8)	= 794.2 kJ/m^2
Exponent N	= .3381
Coefficient C	= 370 kJ/m^2
T (average)	= 153

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 292.4 kJ/m^2	
Kjc	= 237.5 MPa √m	
Slope M	= 115548.9 kJ/m^3	
Intercept B	= 246 kJ/m^2	
T (ASTM)	= 168	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2, 3 (.75 vs .36)	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.44 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.72 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 0



TEST SPECIMEN DATA

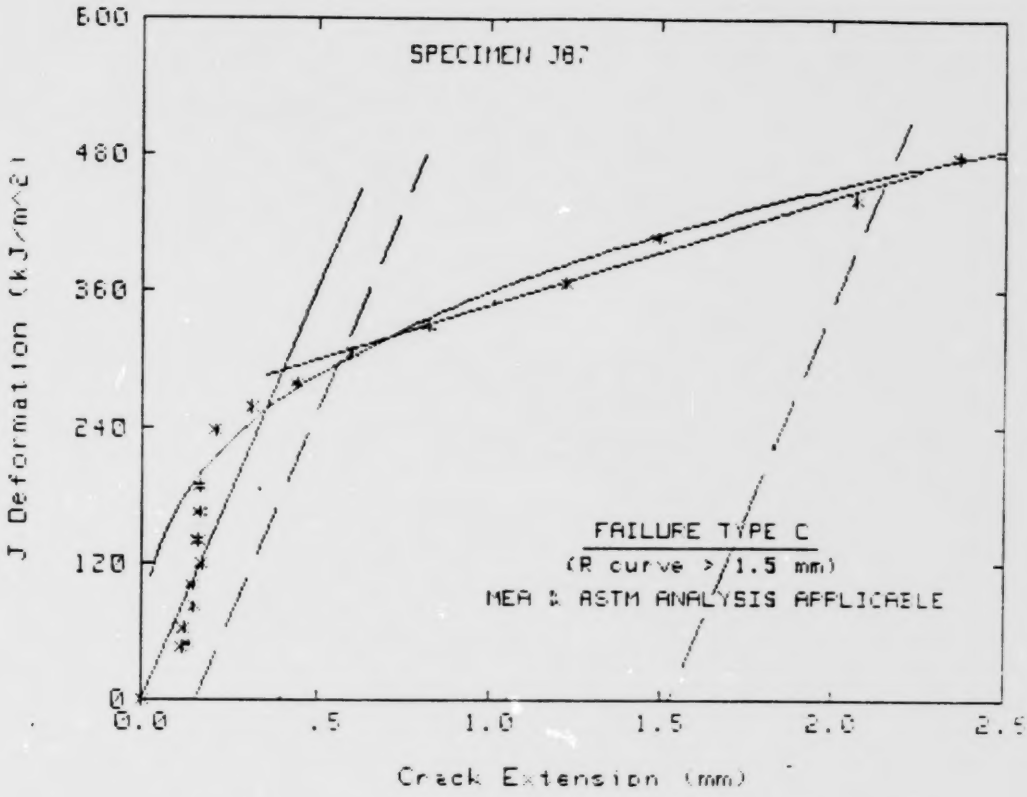
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.43 mm	Init a/W = .52
Final Crack Length	= 39.91 mm	Final a/W = .785
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 794.2 kJ/m^2
Jic	= 286.9 kJ/m^2
Kjc	= 235.3 MPa √m
Exponent N	= .4384
Coefficient C	= 374 kJ/m^2
T (average)	= 204

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 292.4 kJ/m^2
Kjc	= 237.5 MPa √m
Slope M	= 115548.9 kJ/m^3
Intercept B	= 246 kJ/m^2
T (ASTM)	= 168
Validity (Jic)	= VALID
Validity (R-curve)	= INVALID--2, 3 (.75 vs .36)
J maximum allowed	= 370.2 kJ/m^2 (Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.44 mm (Delta a max = 0.1*bo)
Final Delta a	= 12.72 mm
Poisson's Ratio (v)	= 0
Points Left	= 1 Points Right = 8



TEST SPECIMEN DATA

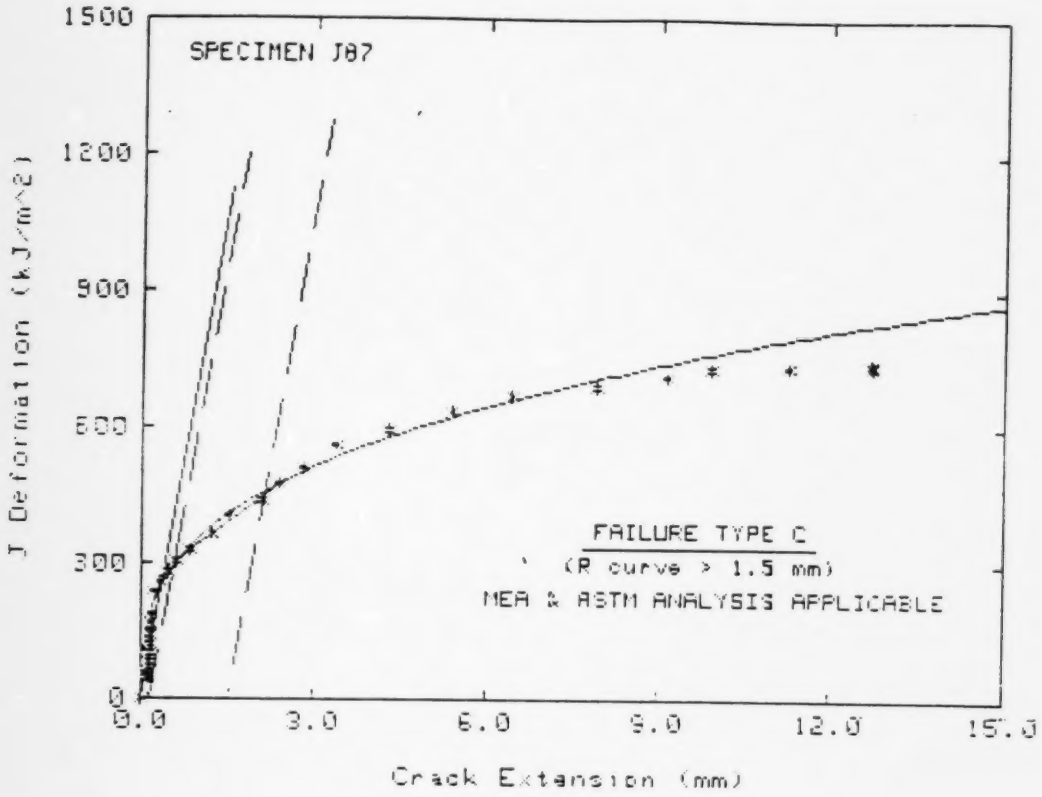
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.43 mm	Init a/W = .52
Final Crack Length	= 39.91 mm	Final a/W = .785
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value

POWER LAW DATA J = C (Delta a)^N

Jic	= 296.8 kJ/m^2
Kjc	= 239.3 MPa √m
J (@J/T=8.8)	= 574.3 kJ/m^2
Exponent N	= .3285
Coefficient C	= 359.1 kJ/m^2
T (average)	= 146

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 290.6 kJ/m^2	
Kjc	= 236.8 MPa √m	
Slope M	= 94470.3 kJ/m^3	
Intercept B	= 252.9 kJ/m^2	
T (ASTM)	= 137	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2, 3 (.75 vs .36)	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.44 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.72 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 8



TEST SPECIMEN DATA

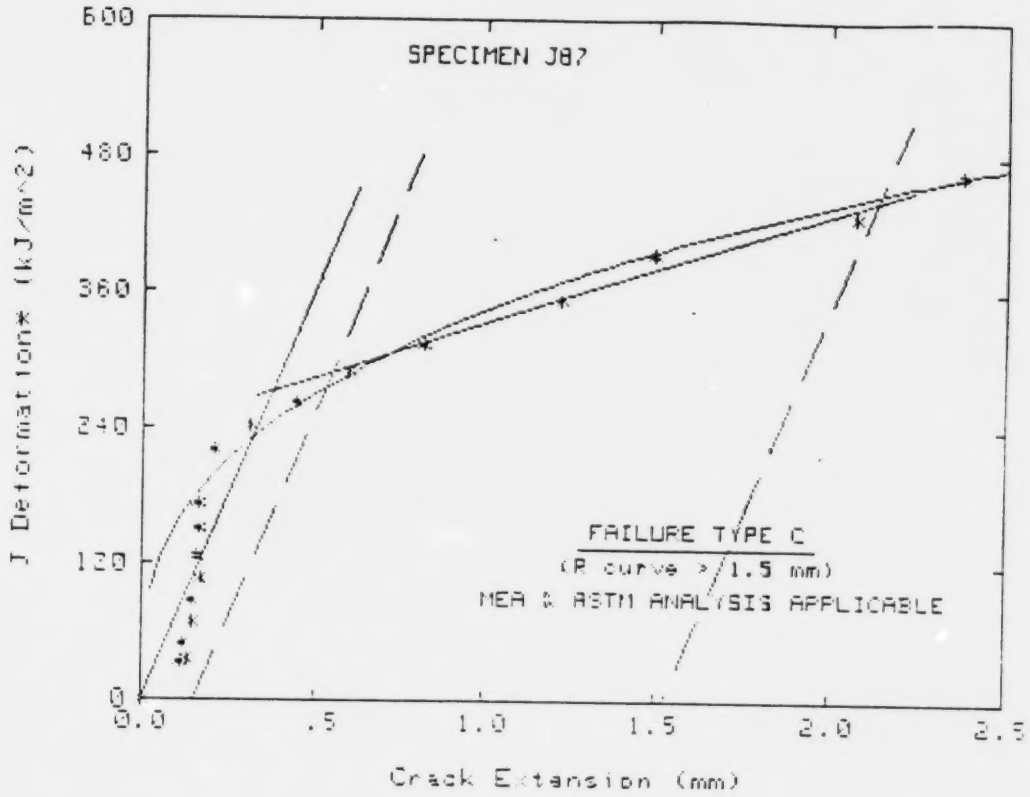
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.43 mm	Init a/W = .52
Final Crack Length	= 39.91 mm	Final a/W = .785
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J-T=8.8)	= 574.3 kJ/m^2
Jic	= 296.8 kJ/m^2
Kjc	= 239.3 MPa √m
Exponent N	= .3285
Coefficient C	= 359.1 kJ/m^2
T (average)	= 146

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 290.6 kJ/m^2
Kjc	= 236.8 MPa √m
Slope M	= 94470.3 kJ/m^3
Intercept B	= 252.9 kJ/m^2
T (ASTM)	= 137
Validity (Jic)	= VALID
Validity (R-curve)	= INVALID--2, 3 (.75 vs .36)
J maximum allowed	= 370.2 kJ/m^2 (Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.44 mm (Delta a max = 0.1*bo)
Final Delta a	= 12.72 mm
Poisson's Ratio (v)	= 0
Points Left	= 1 Points Right = 8



TEST SPECIMEN DATA

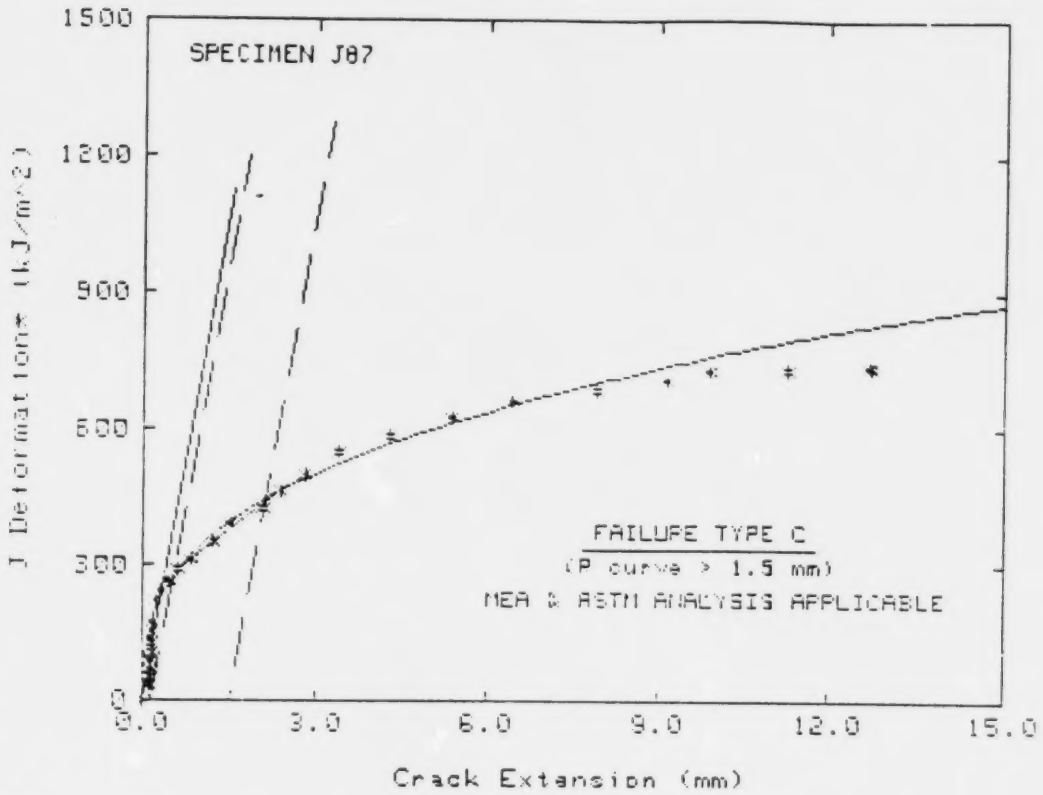
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.43 mm	Init a/W = .52
Final Crack Length	= 39.91 mm	Final a/W = .785
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 275.9 kJ/m^2
Kjc	= 230.7 MPa √m
J (@J/T=8.8)	= 573.9 kJ/m^2
Exponent N	= .3464
Coefficient C	= 343.5 kJ/m^2
T (average)	= 150

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 272.2 kJ/m^2	
Kjc	= 229.2 MPa √m	
Slope M	= 95500.9 kJ/m^3	
Intercept B	= 236.5 kJ/m^2	
T (ASTM)	= 139	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2, 3 (.75 vs .36)	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.44 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.72 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 8



TEST SPECIMEN DATA

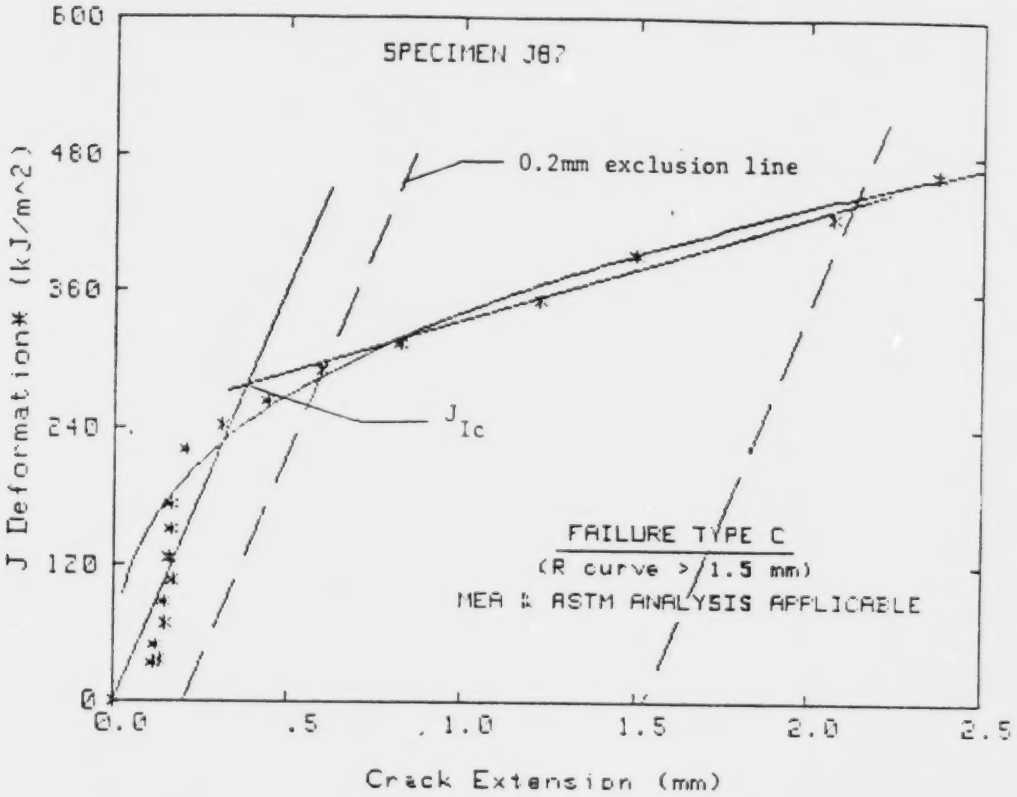
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.43 mm	Init a/W = .52
Final Crack Length	= 39.91 mm	Final a/W = .785
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 573.9 kJ/m^2
Jic	= 275.9 kJ/m^2
Kjc	= 230.7 MPa √m
Exponent N	= .3464
Coefficient C	= 343.5 kJ/m^2
T (average)	= 150

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 272.2 kJ/m^2	
Kjc	= 229.2 MPa √m	
Slope M	= 95500.9 kJ/m^3	
Intercept B	= 236.5 kJ/m^2	
T (ASTM)	= 139	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2, 3 (.75 vs .36)	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.44 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.72 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 8



TEST SPECIMEN DATA

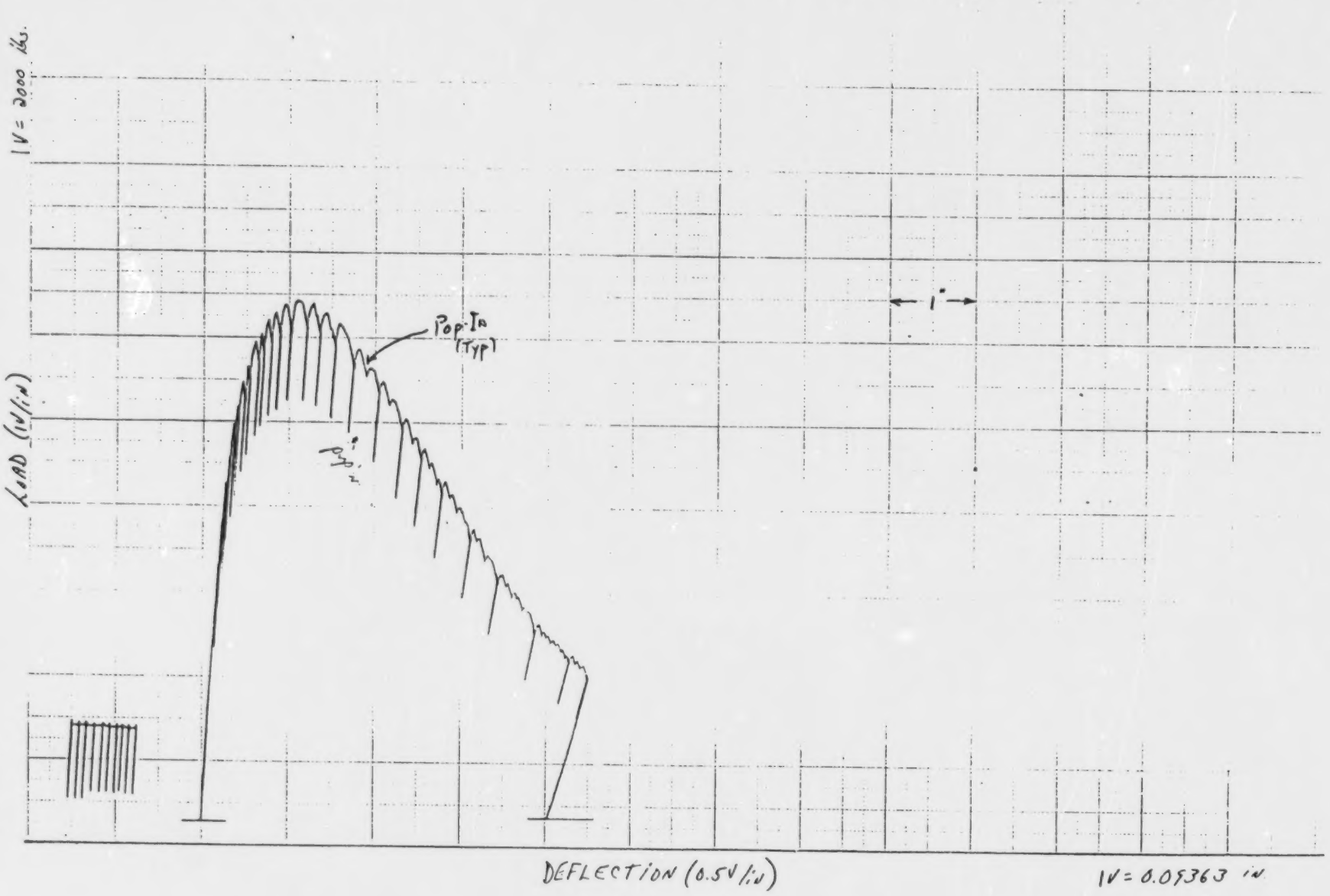
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Init crack length	= 26.43 mm	Init a/W = .52
Final crack length	= 39.91 mm	Final a/W = .785
Flow stress	= 364.6 MPa	
Youngs modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 283.7 kJ/m^2
Kjc	= 233.9 MPa √m
J (@J/T=8.8)	= 576.7 kJ/m^2
Exponent N	= .3507
Coefficient C	= 341.5 kJ/m^2
T (average)	= 148

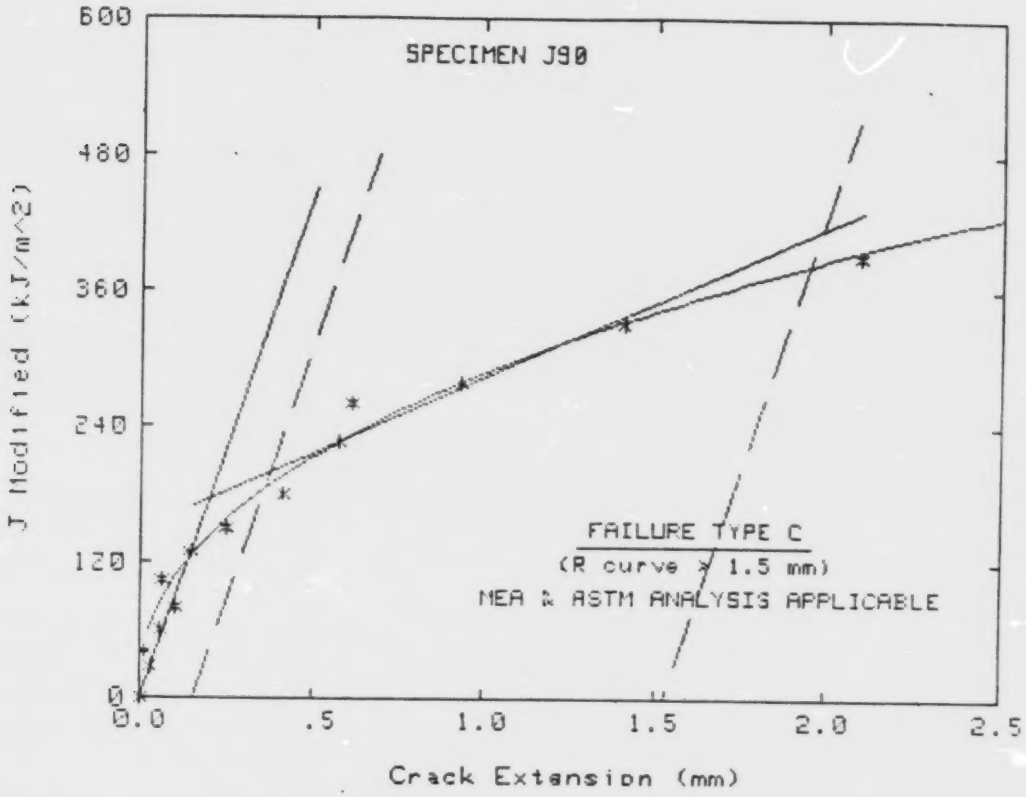
LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 277.2 kJ/m^2	
Kjc	= 231.2 MPa √m	
Slope M	= 92110.1 kJ/m^3	
Intercept B	= 242.2 kJ/m^2	
T (ASTM)	= 134	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2, 3 (.76 vs .36)	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.44 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.72 mm	
Poisson's Ratio (v)	= 0	


LRF 4/4/86 J89 IT-CT 20256 250°C
1V = 2000 lbs.
LOAD (lbs/in)
Pop-In (TYP)
1"
DEFLECTION (0.5V/in)
1V = 0.05363 in

48

87-262



TEST SPECIMEN DATA

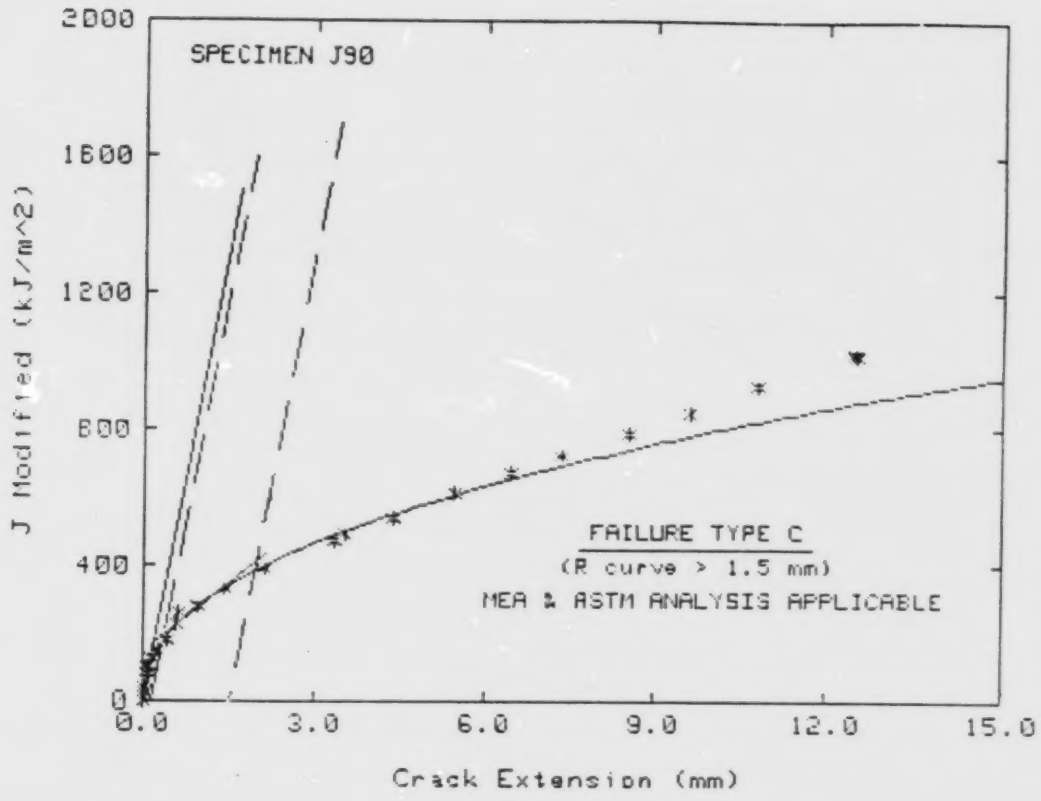
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 25.8 mm	Init a/W = .507
Final Crack Length	= 38.69 mm	Final a/W = .761
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 185 kJ/m^2
Kjc	= 188.9 MPa √m
J (@J/T=8.8)	= 513.6 kJ/m^2
Exponent N	= .43
Coefficient C	= 287.4 kJ/m^2
T (average)	= 115

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 176.4 kJ/m^2	
Kjc	= 184.4 MPa √m	
Slope M	= 133420.2 kJ/m^3	
Intercept B	= 150.1 kJ/m^2	
T (ASTM)	= 128	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2, 3 (.39 vs .37)	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.5 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.49 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 2	Points Right = 1



TEST SPECIMEN DATA

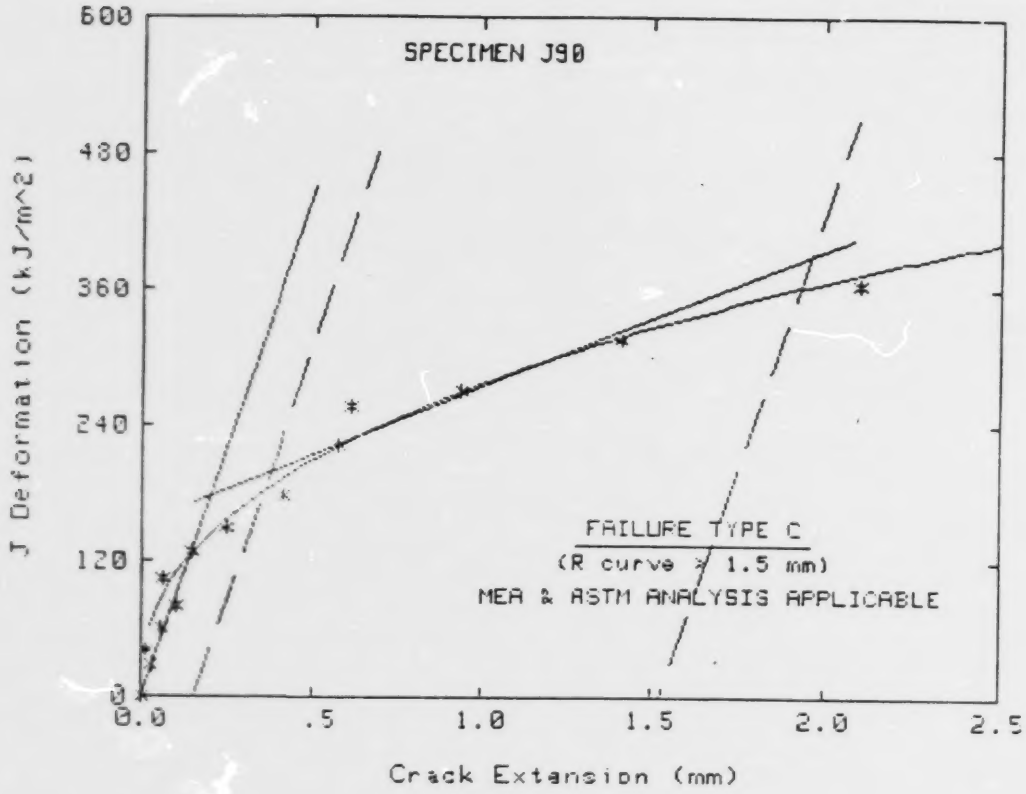
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 25.8 mm	Init a/W = .507
Final Crack Length	= 38.69 mm	Final a/W = .761
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 513.6 kJ/m^2	
Jic	= 180.9 kJ/m^2	
Kjc	= 186.8 MPa \/m	
Exponent N	= .4434	
Coefficient C	= 286.5 kJ/m^2	
T (average)	= 118	

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 176.4 kJ/m^2	
Kjc	= 184.4 MPa \/m	
Slope M	= 133420.2 kJ/m^3	
Intercept B	= 150.1 kJ/m^2	
T (ASTM)	= 128	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2, 3 (.39 vs .37)	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.5 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.49 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 6



TEST SPECIMEN DATA

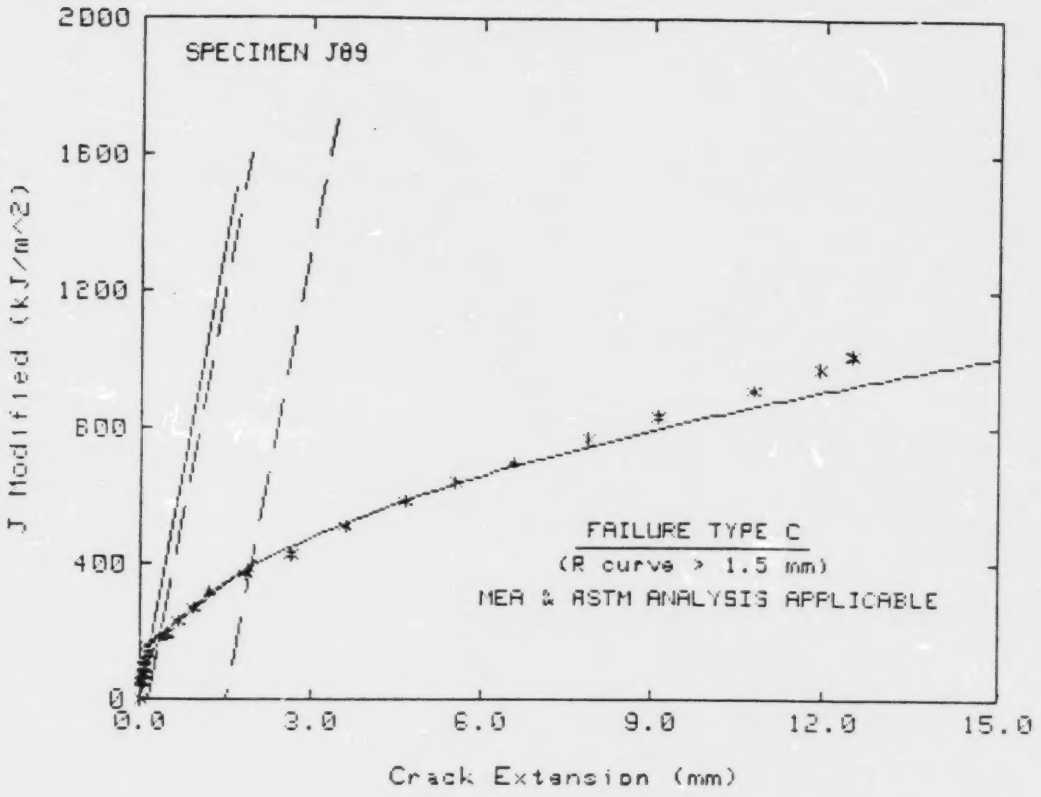
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 25.8 mm	Init a/W = .507
Final Crack Length	= 38.69 mm	Final a/W = .761
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 181.8 kJ/m^2
Kjc	= 187.3 MPa √m
J (@J/T=8.8)	= 419.1 kJ/m^2
Exponent N	= .4063
Coefficient C	= 276.8 kJ/m^2
T (average)	= 105

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 177.5 kJ/m^2
Kjc	= 185.1 MPa √m
Slope M	= 120647.2 kJ/m^3
Intercept B	= 153.6 kJ/m^2
T (ASTM)	= 116
Validity (Jic)	= VALID
Validity (R-curve)	= INVALID--2, 3 (.39 vs .37)
J maximum allowed	= 454.8 kJ/m^2 (Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.5 mm (Delta a max = 0.1*bo).
Final Delta a	= 12.49 mm
Poisson's Ratio (v)	= 0.
Points Left	= 2 Points Right = 1



TEST SPECIMEN DATA

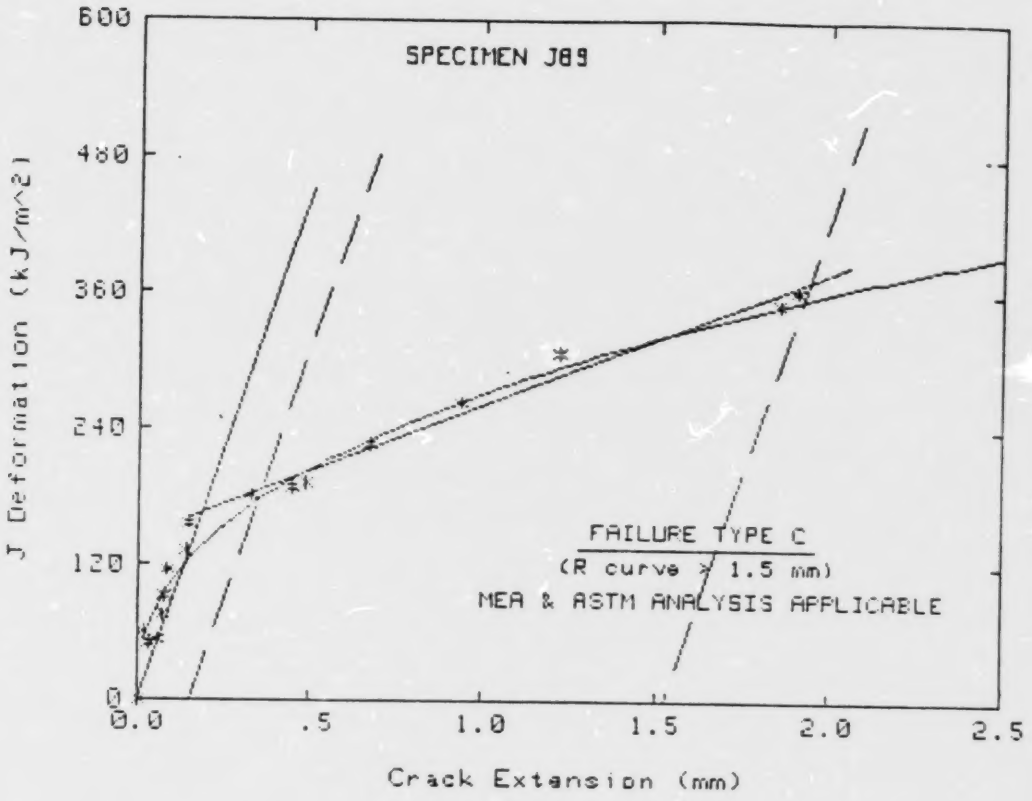
Material Type	= WELD		
Test Temperature	= 250 C		
Percent Side Groove	= 20 %		
Specimen Thickness	= 25.4 mm		
Initial Crack Length	= 25.48 mm	Init a/W	= .501
Final Crack Length	= 38.2 mm	Final a/W	= .751
Flow Stress	= 448 MPa		
Youngs Modulus	= 192900 MPa	(Estimated Value)	

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 540.1 kJ/m^2	
Jic	= 172.4 kJ/m^2	
Kjc	= 182.4 MPa √m	
Exponent N	= .4687	
Coefficient C	= 283.9 kJ/m^2	
T (average)	= 124	

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 165.1 kJ/m^2	
Kjc	= 178.5 MPa √m	
Slope M	= 129779.5 kJ/m^3	
Intercept B	= 141.2 kJ/m^2	
T (ASTM)	= 125	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.53 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.5 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 6



TEST SPECIMEN DATA

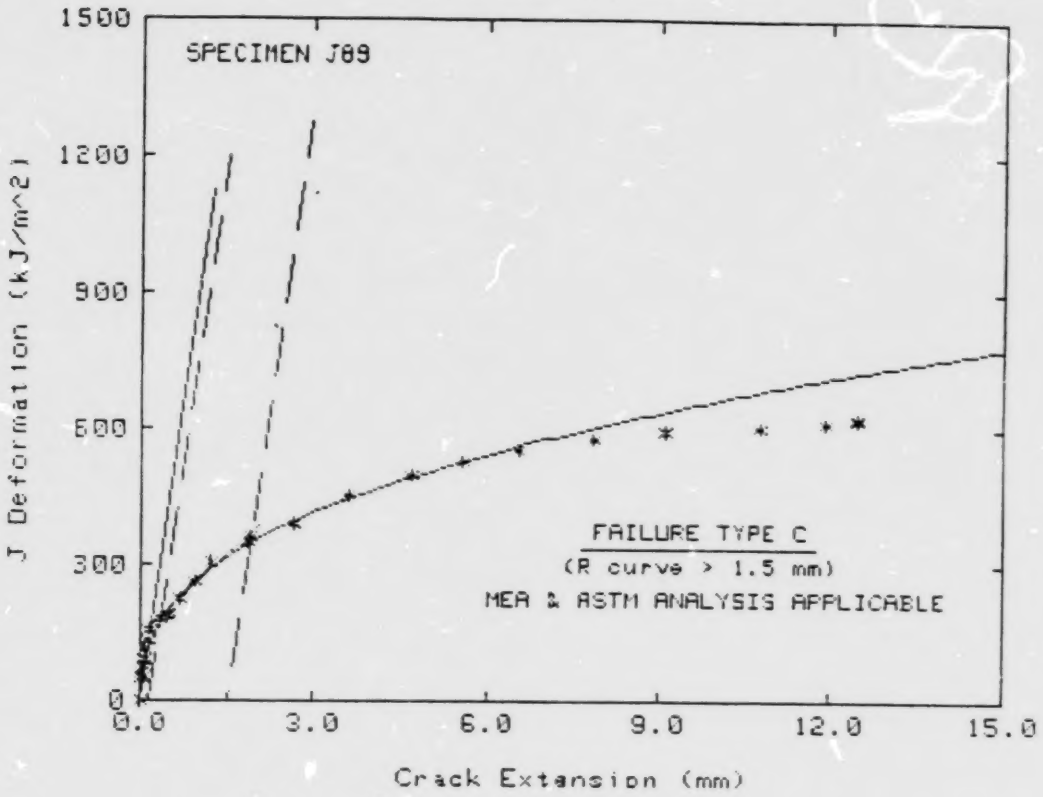
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 25.48 mm	Init a/W = .501
Final Crack Length	= 38.2 mm	Final a/W = .751
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 176 kJ/m^2
Kjc	= 184.3 MPa √m
J (@J/T=8.8)	= 429.8 kJ/m^2
Exponent N	= .4098
Coefficient C	= 270.9 kJ/m^2
T (average)	= 105

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 167.2 kJ/m^2	
Kjc	= 179.6 MPa √m	
Slope M	= 115849 kJ/m^3	
Intercept B	= 145.6 kJ/m^2	
T (ASTM)	= 111	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.53 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.5 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 1



TEST SPECIMEN DATA

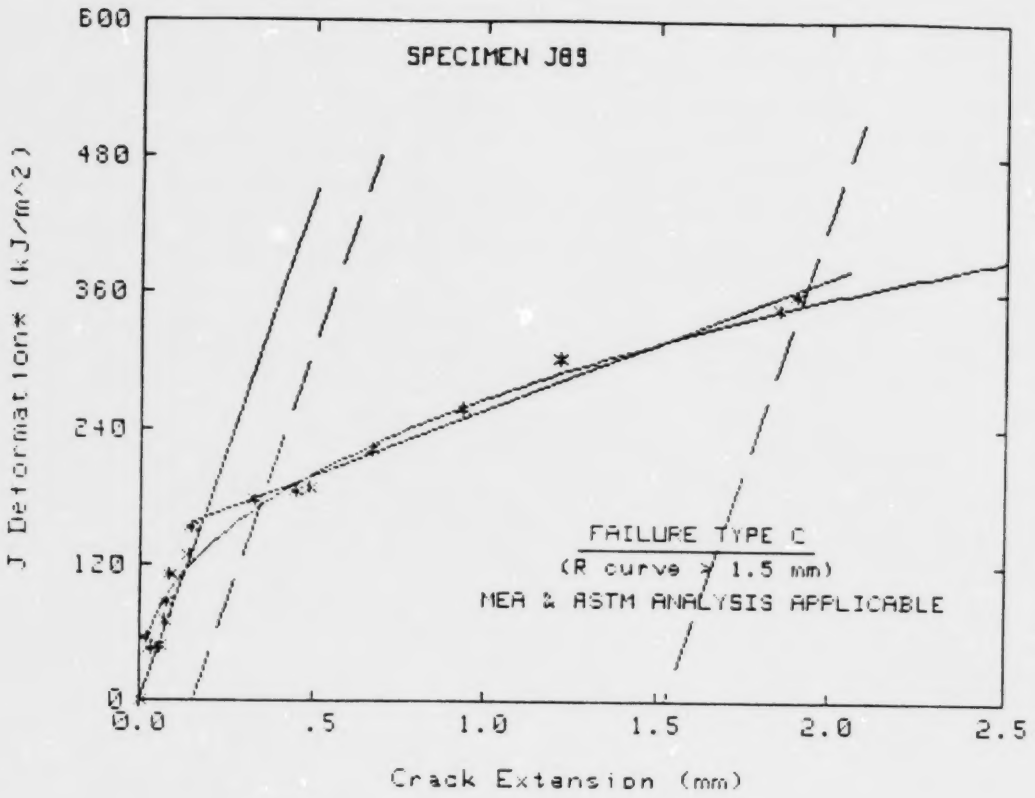
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 25.48 mm	Init a/W = .501
Final Crack Length	= 38.2 mm	Final a/W = .751
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 429.8 kJ/m^2
Jic	= 179.4 kJ/m^2
Kjc	= 186 MPa √m
Exponent N	= .3912
Coefficient C	= 269.7 kJ/m^2
T (average)	= 99

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 167.2 kJ/m^2	
Kjc	= 179.6 MPa √m	
Slope M	= 115849 kJ/m^3	
Intercept B	= 145.6 kJ/m^2	
T (ASTM)	= 111	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.53 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.5 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 6



TEST SPECIMEN DATA

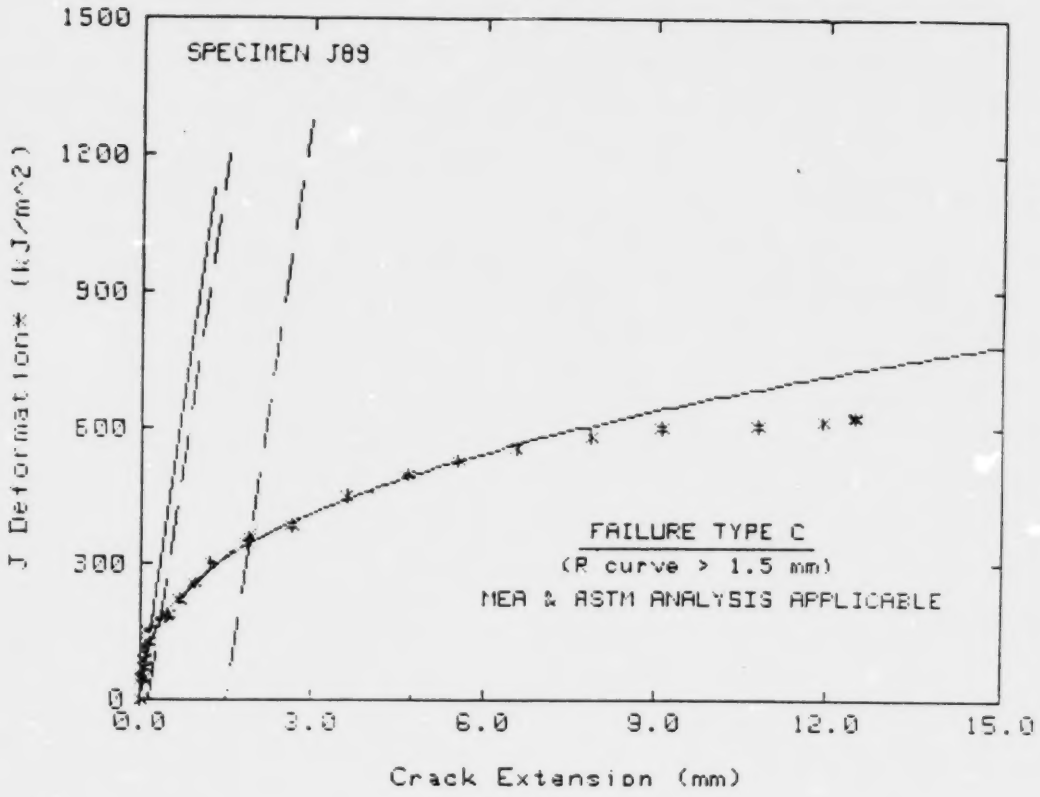
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 25.48 mm	Init a/W = .501
Final Crack Length	= 38.2 mm	Final a/W = .751
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 171.5 kJ/m^2
Kjc	= 181.9 MPa √m
J (@J/T=8.8)	= 431.2 kJ/m^2
Exponent N	= .4139
Coefficient C	= 266.7 kJ/m^2
T (average)	= 104

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 162.7 kJ/m^2	
Kjc	= 177.2 MPa √m	
Slope M	= 115658.9 kJ/m^3	
Intercept B	= 141.7 kJ/m^2	
T (ASTM)	= 111	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.53 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.5 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 1



TEST SPECIMEN DATA

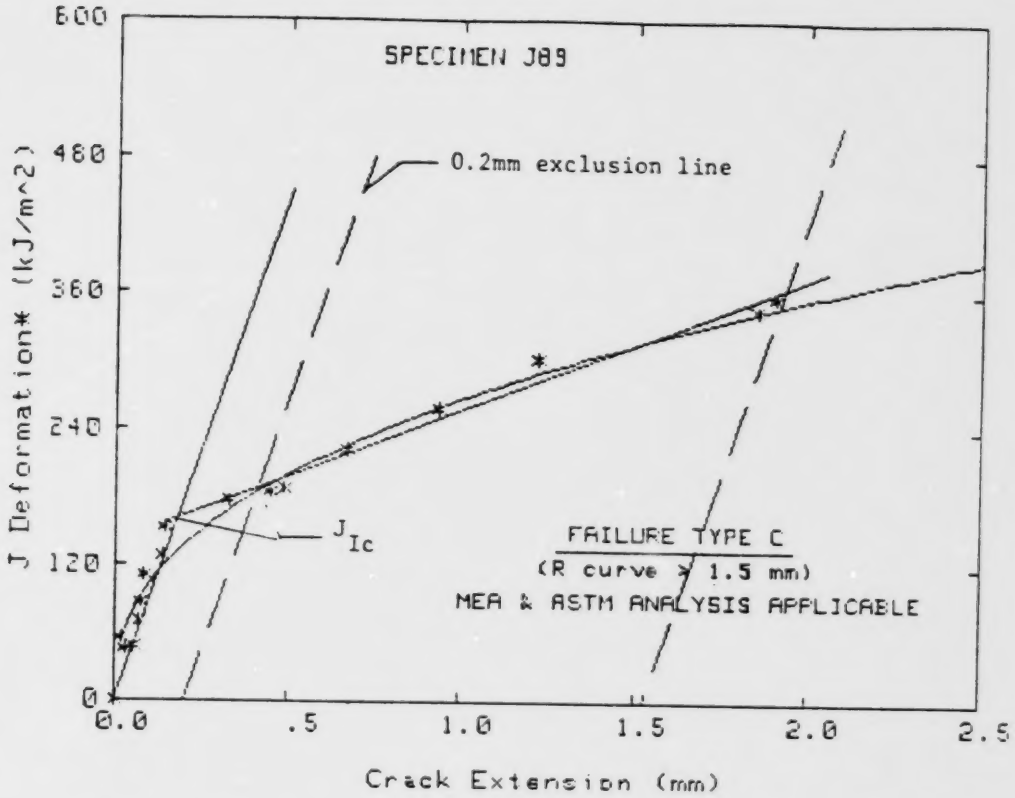
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 25.48 mm	Init a/W = .501
Final Crack Length	= 38.2 mm	Final a/W = .751
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 431.2 kJ/m^2
Jic	= 174.2 kJ/m^2
Kjc	= 183.3 MPa √m
Exponent N	= .3992
Coefficient C	= 265.8 kJ/m^2
T (average)	= 100

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 162.7 kJ/m^2	
Kjc	= 177.2 MPa √m	
Slope M	= 115658.9 kJ/m^3	
Intercept B	= 141.7 kJ/m^2	
T (ASTM)	= 111	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.53 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.5 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 6



TEST SPECIMEN DATA

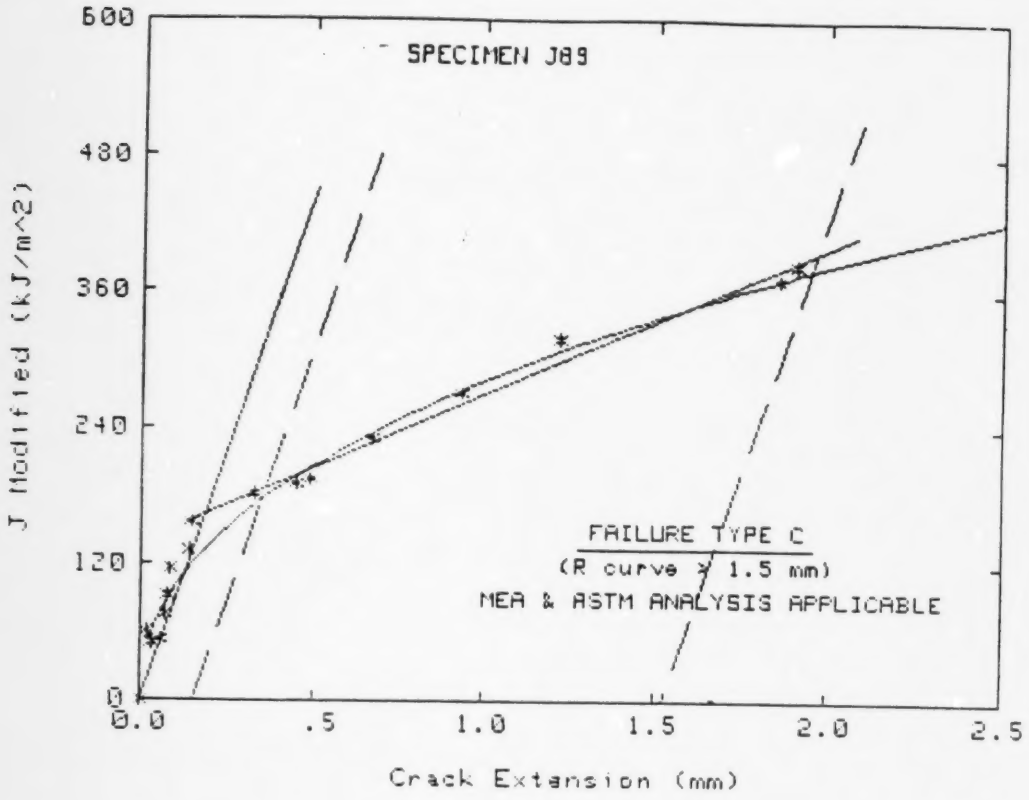
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Init crack length	= 25.48 mm	Init a/W = .501
Final crack length	= 38.2 mm	Final a/W = .752
Flow stress	= 448 MPa	
Youngs modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 183.4 kJ/m^2
Kjc	= 188.1 MPa √m
J (@J/T=0.8)	= 431.2 kJ/m^2
Exponent N	= .4139
Coefficient C	= 266.7 kJ/m^2
T (average)	= 102

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 162.7 kJ/m^2	
Kjc	= 177.2 MPa √m	
Slope M	= 115658.9 kJ/m^3	
Intercept B	= 141.7 kJ/m^2	
T (ASTM)	= 111	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.9 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.53 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.5 mm	
Poisson's Ratio (v)	= 0	



TEST SPECIMEN DATA

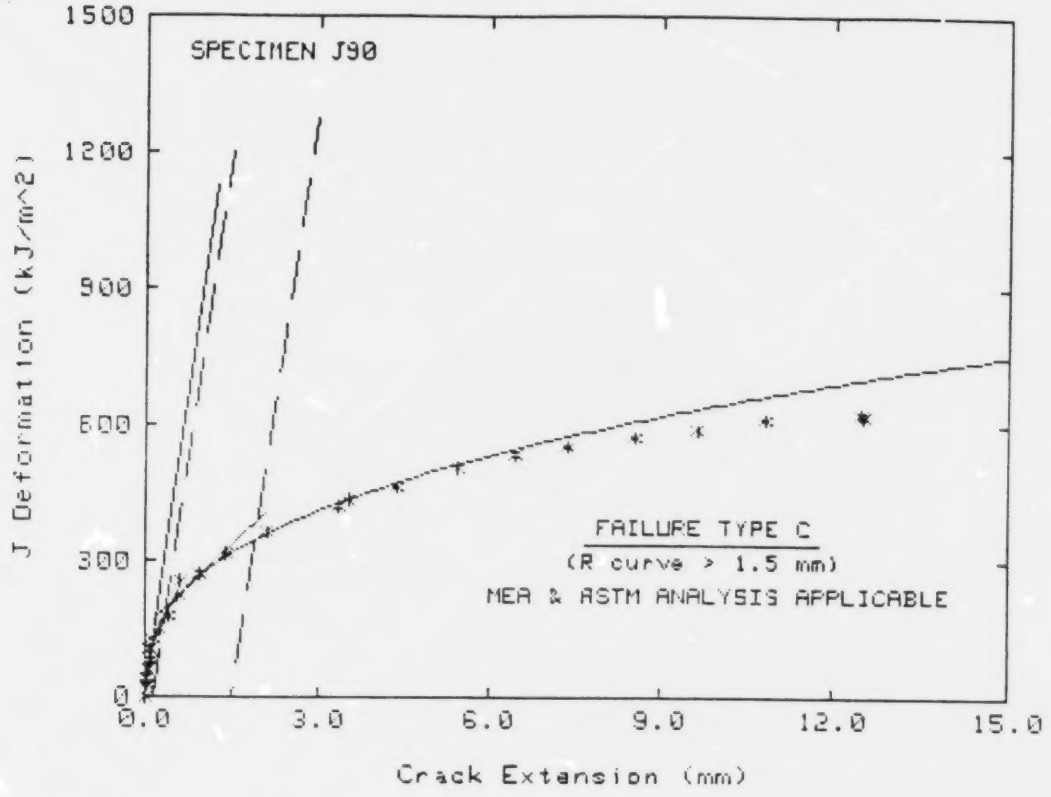
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 25.48 mm	Init a/W = .501
Final Crack Length	= 38.2 mm	Final a/W = .751
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 176.6 kJ/m^2
Kjc	= 184.6 MPa √m
J (@J/T=8.8)	= 540.1 kJ/m^2
Exponent N	= .4453
Coefficient C	= 281.9 kJ/m^2
T (average)	= 117

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 165.1 kJ/m^2	
Kjc	= 178.5 MPa √m	
Slope M	= 129779.5 kJ/m^3	
Intercept B	= 141.2 kJ/m^2	
T (ASTM)	= 125	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.53 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.5 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 1



TEST SPECIMEN DATA

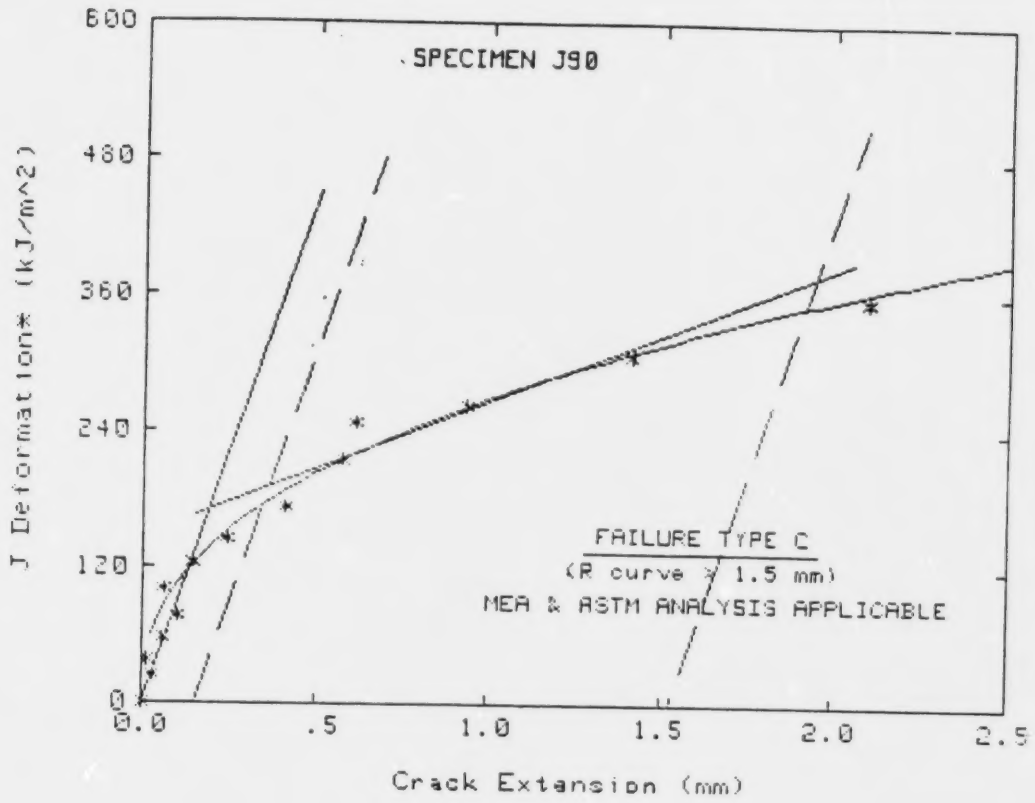
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 25.8 mm	Init a/W = .507
Final Crack Length	= 38.69 mm	Final a/W = .761
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 419.1 kJ/m^2
Jic	= 183.6 kJ/m^2
Kjc	= 188.2 MPa √m
Exponent N	= .3777
Coefficient C	= 270.8 kJ/m^2
T (average)	= 96

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 177.5 kJ/m^2
Kjc	= 185.1 MPa √m
Slope M	= 120647.2 kJ/m^3
Intercept B	= 153.6 kJ/m^2
T (ASTM)	= 116
Validity (Jic)	= VALID
Validity (R-curve)	= INVALID--2, 3 (.39 vs .37)
J maximum allowed	= 454.8 kJ/m^2 (Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.5 mm (Delta a max = 0.1*bo)
Final Delta a	= 12.49 mm
Poisson's Ratio (v)	= 0
Points Left	= 1 Points Right = 6



TEST SPECIMEN DATA

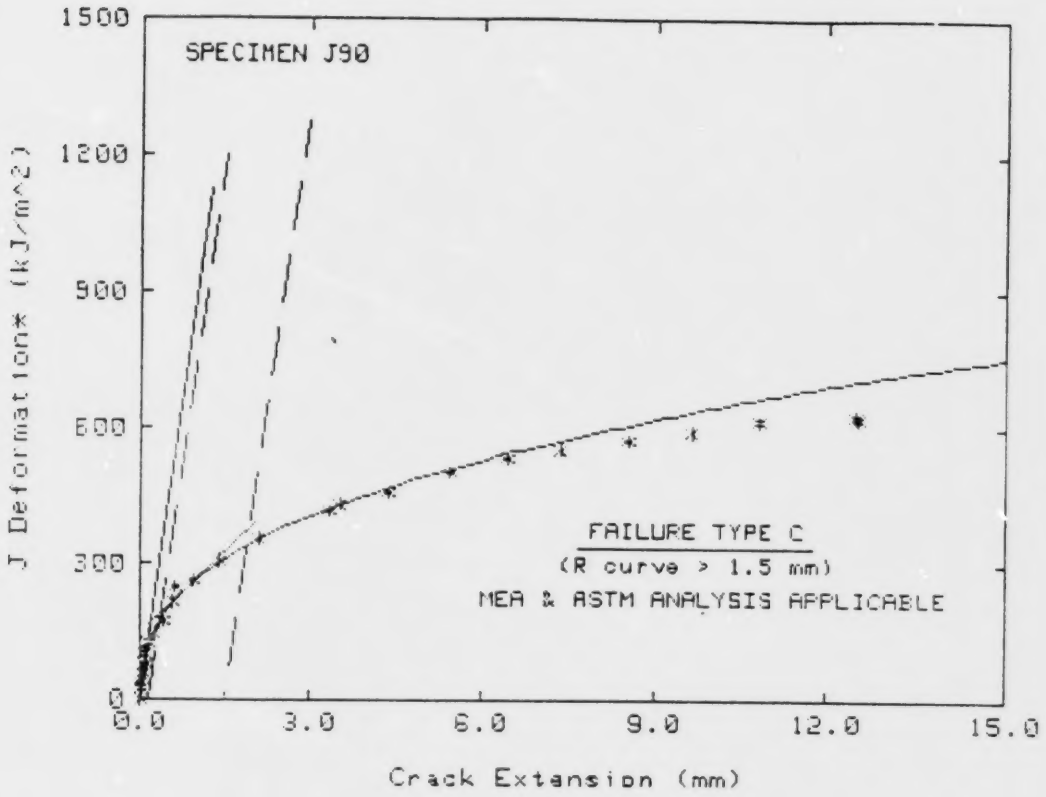
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 25.8 mm	Init a/W = .507
Final Crack Length	= 38.69 mm	Final a/W = .761
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 174.5 kJ/m^2
Kjc	= 183.5 MPa √m
J (@J/T=8.8)	= 418 kJ/m^2
Exponent N	= .4084
Coefficient C	= 268.8 kJ/m^2
T (average)	= 104

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 170.2 kJ/m^2
Kjc	= 181.2 MPa √m
Slope M	= 117942.8 kJ/m^3
Intercept B	= 147.8 kJ/m^2
T (ASTM)	= 113
Validity (Jic)	= VALID
Validity (R-curve)	= INVALID--2, 3 (.39 vs .37)
J maximum allowed	= 454.8 kJ/m^2 (Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.5 mm (Delta a max = 0.1*bo)
Final Delta a	= 12.49 mm
Poissor's Ratio (v)	= 0
Points Left	= 2 Points Right = 1



TEST SPECIMEN DATA

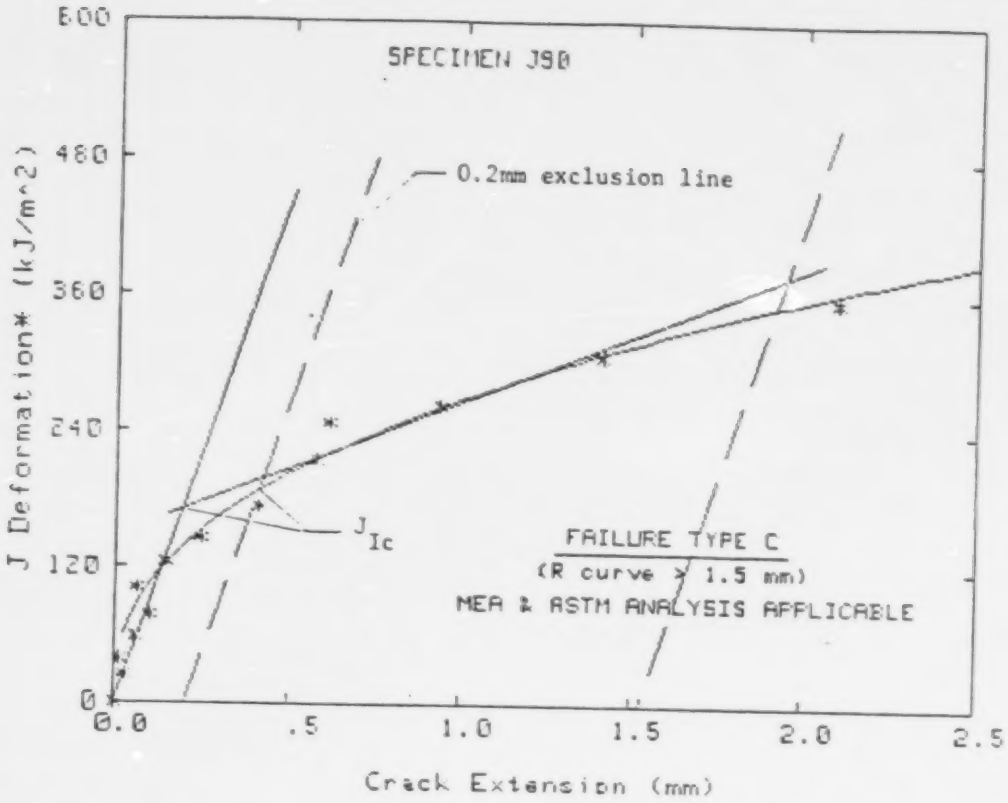
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 25.8 mm	Init a/W = .507
Final Crack Length	= 38.69 mm	Final a/W = .761
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 418 kJ/m^2
Jic	= 175.3 kJ/m^2
Kjc	= 183.9 MPa \/m
Exponent N	= .3882
Coefficient C	= 264 kJ/m^2
T (average)	= 97

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

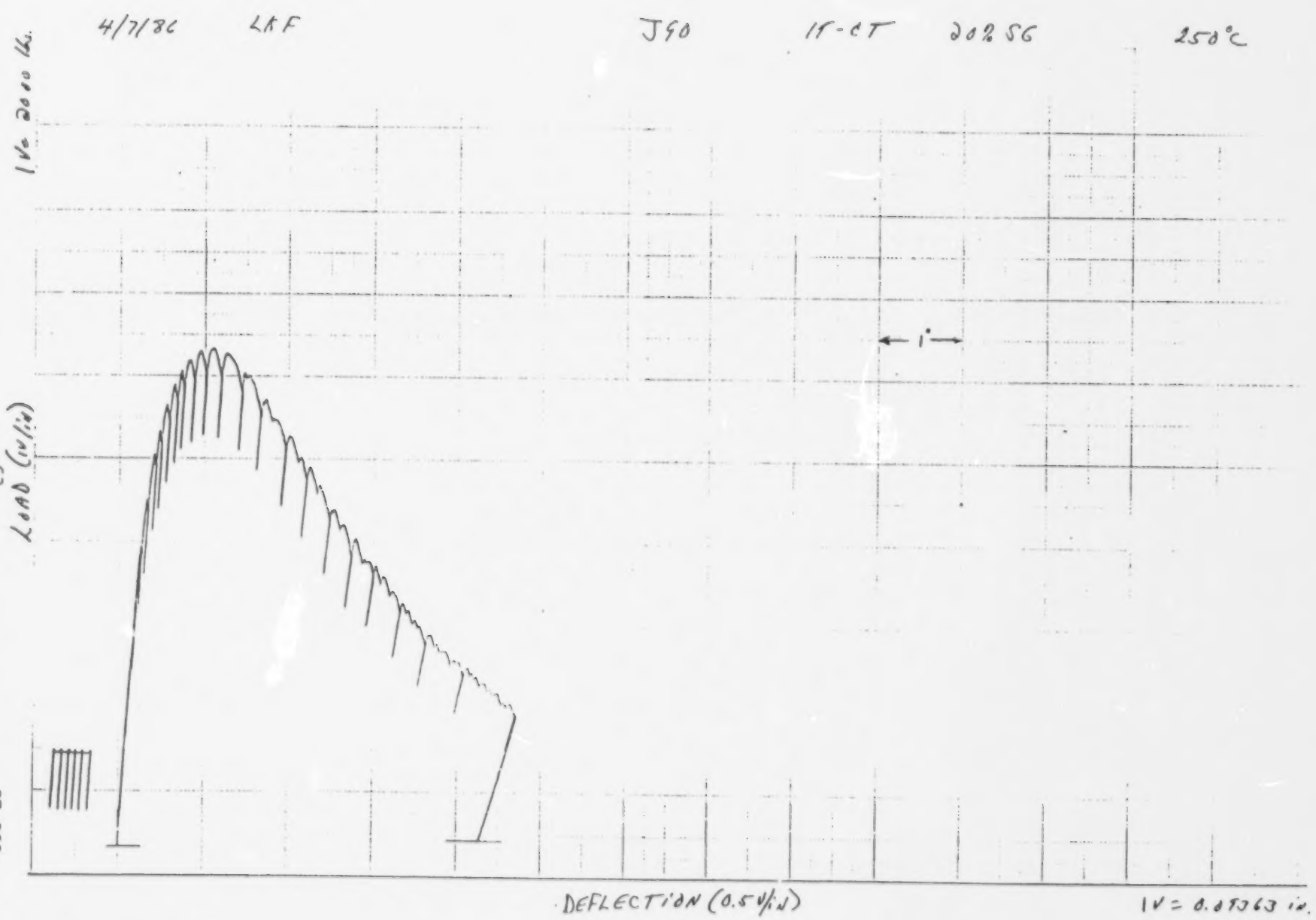
Jic	= 170.2 kJ/m^2	
Kjc	= 181.2 MPa \/m	
Slope M	= 117942.8 kJ/m^3	
Intercept B	= 147.8 kJ/m^2	
T (ASTM)	= 113	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2, 3 (.39 vs .37)	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.5 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.49 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 6

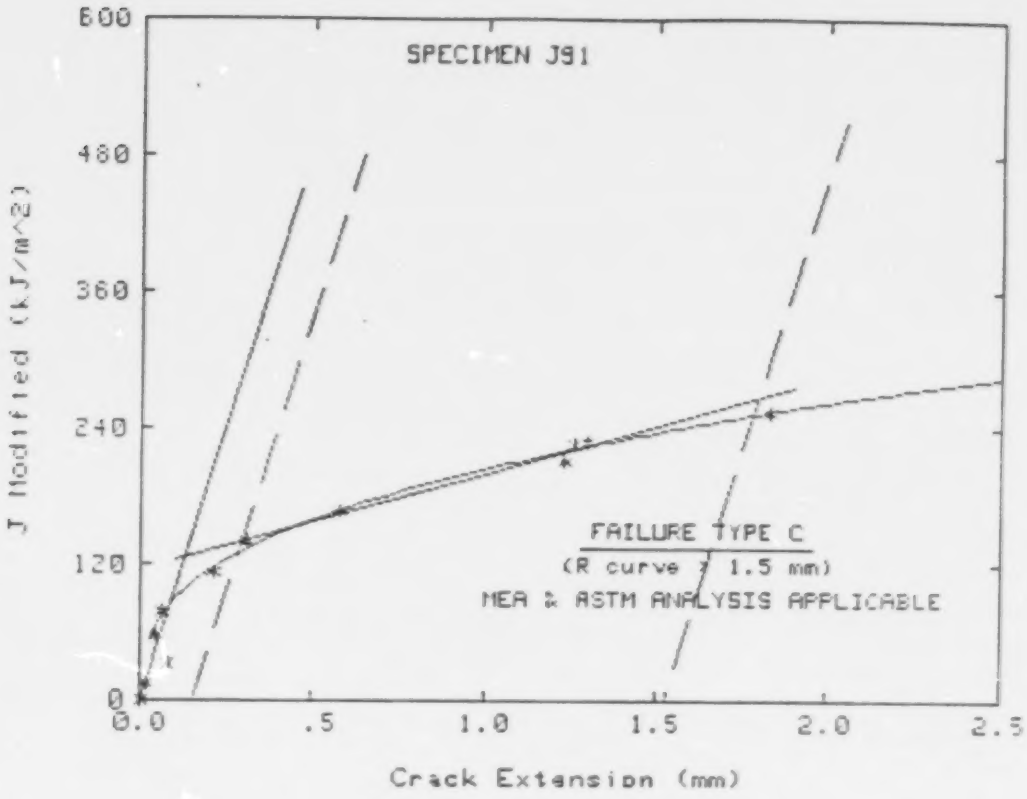


TEST SPECIMEN DATA		
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Init crack length	= 25.8 mm	Init a/W = .507
Final crack length	= 38.69 mm	Final a/W = .761
Flow stress	= 448 MPa	
Youngs modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N	
Jic	= 186.4 kJ/m^2
Kjc	= 189.6 MPa √m
J (@J/T=8.8)	= 418 kJ/m^2
Exponent N	= .4084
Coefficient C	= 268.8 kJ/m^2
T (average)	= 101

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B	
Jic	= 170.2 kJ/m^2
Kjc	= 181.2 MPa √m
Slope M	= 117942.8 kJ/m^3
Intercept B	= 147.8 kJ/m^2
T (ASTM)	= 113
Validity (Jic)	= VALID
Validity (R-curve)	= INVALID--2, 3 (.4 vs .37)
J maximum allowed	= 454.9 kJ/m^2 (Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.5 mm (Delta a max = 0.1*bo)
Final Delta a	= 12.49 mm
Poisson's Ratio (v)	= 0


4/7/86 LRF J90 IT-CT 20%S6 250°C
1V = 2000 lb.
LOAD (1V/in)
63
87-262
DEFLECTION (0.5 V/in)
1V = 0.0563 in.



TEST SPECIMEN DATA

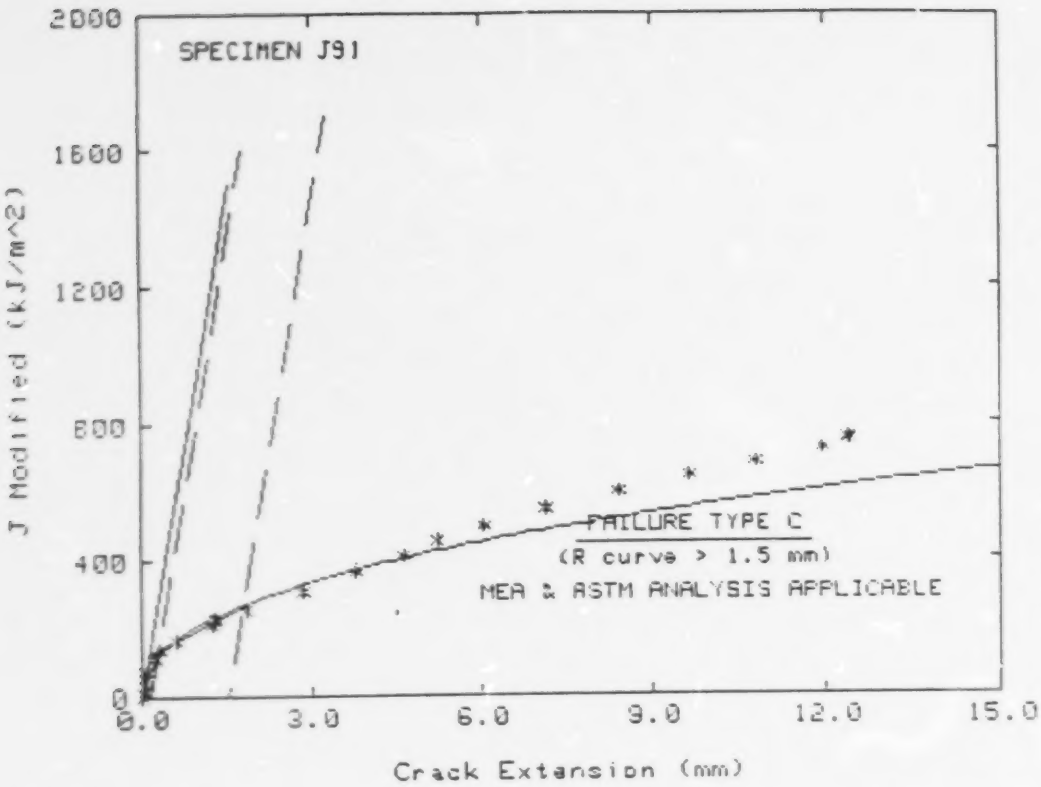
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 488 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 130.2 kJ/m^2
Kjc	= 158.5 MPa √m
J (@J/T=8.8)	= 336.4 kJ/m^2
Exponent N	= .3613
Coefficient C	= 204.7 kJ/m^2
T (average)	= 63

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 126.7 kJ/m^2	
Kjc	= 156.4 MPa √m	
Slope M	= 84614.5 kJ/m^3	
Intercept B	= 115.7 kJ/m^2	
T (ASTM)	= 69	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 495.5 kJ/m^2	(Jmax=Bnet+Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 0



TEST SPECIMEN DATA

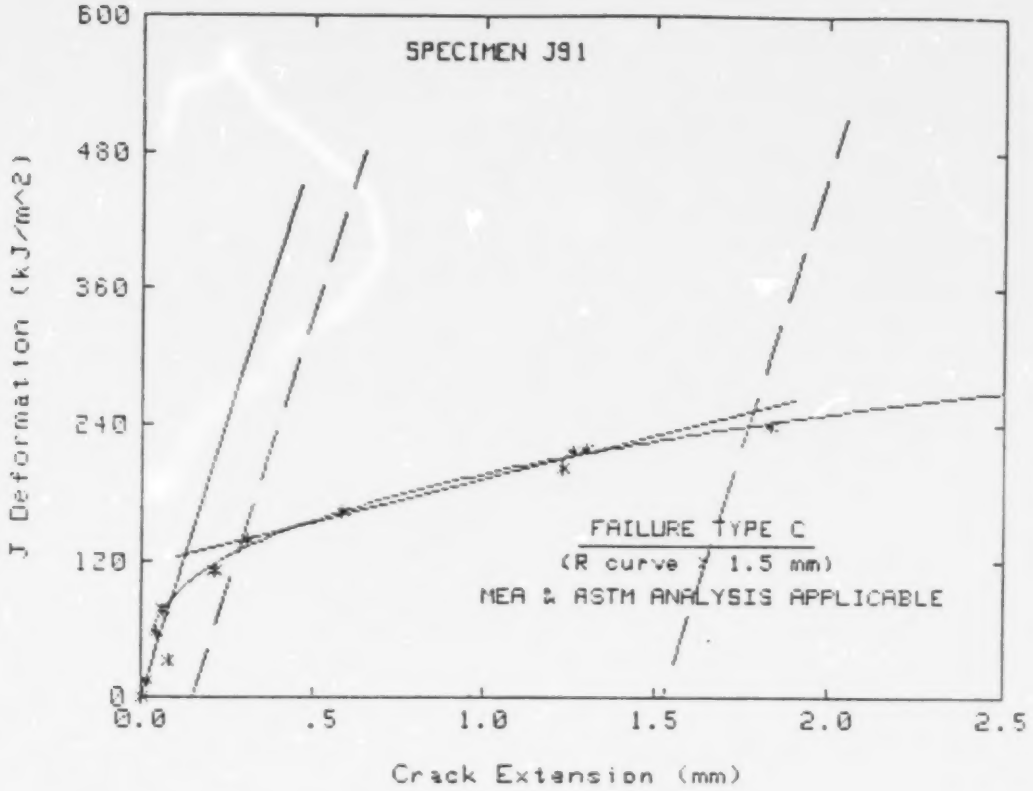
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 488 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 336.4 kJ/m^2
Jic	= 122.9 kJ/m^2
Kjc	= 154 MPa √m
Exponent N	= .4234
Coefficient C	= 211.2 kJ/m^2
T (average)	= 75

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 126.7 kJ/m^2	
Kjc	= 156.4 MPa √m	
Slope M	= 84614.5 kJ/m^3	
Intercept B	= 115.7 kJ/m^2	
T (ASTM)	= 69	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 495.5 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 6



TEST SPECIMEN DATA

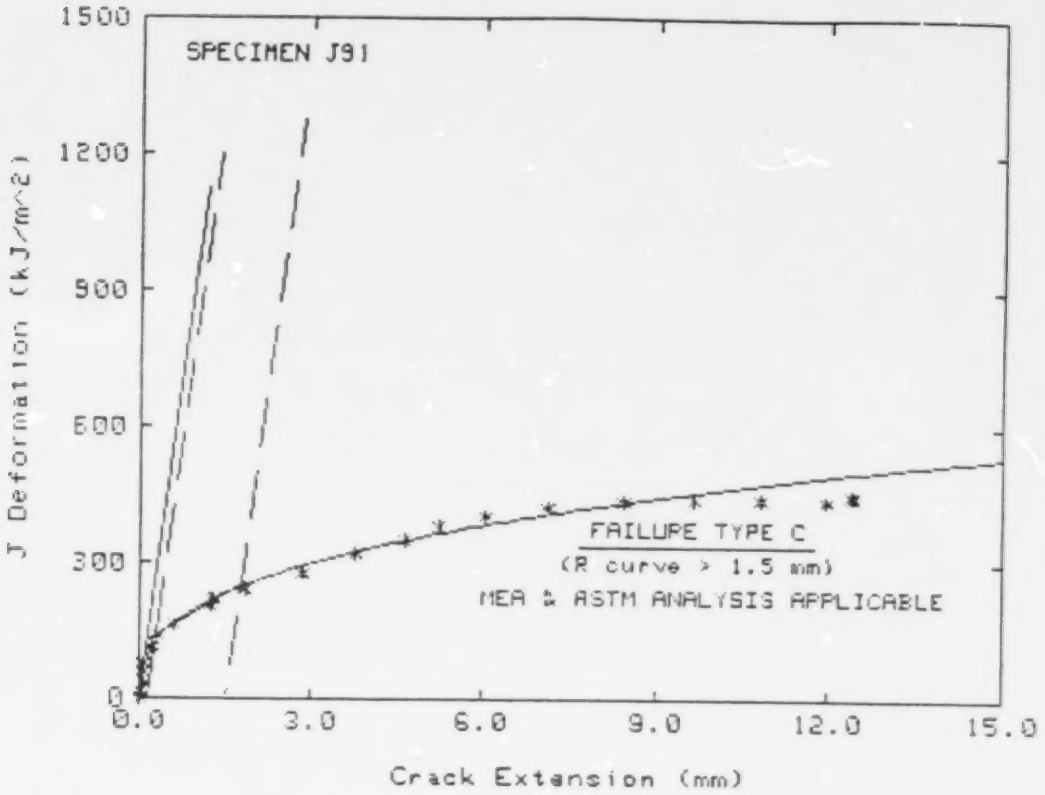
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 488 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 128.9 kJ/m^2
Kjc	= 157.7 MPa √m
J (@J/T=8.8)	= 281.9 kJ/m^2
Exponent N	= .3399
Coefficient C	= 197.6 kJ/m^2
T (average)	= 57

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 127.3 kJ/m^2	
Kjc	= 156.7 MPa √m	
Slope M	= 76202.9 kJ/m^3	
Intercept B	= 117.4 kJ/m^2	
T (ASTM)	= 62	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 495.5 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 0



TEST SPECIMEN DATA

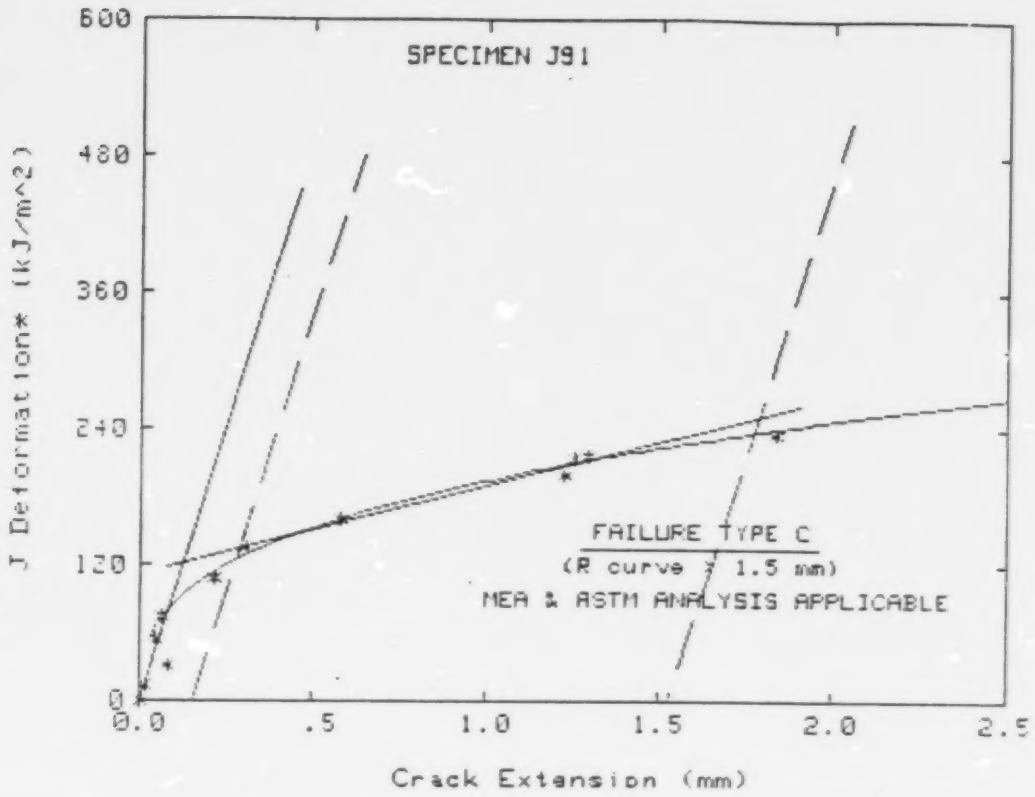
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 488 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.6)	= 281.9 kJ/m^2
Jic	= 125.7 kJ/m^2
Kjc	= 155.7 MPa √m
Exponent N	= .3641
Coefficient C	= 199.6 kJ/m^2
T (average)	= 62

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 127.3 kJ/m^2	
Kjc	= 156.7 MPa √m	
Slope M	= 76202.9 kJ/m^3	
Intercept B	= 117.4 kJ/m^2	
T (ASTM)	= 62	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 495.5 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 6



TEST SPECIMEN DATA

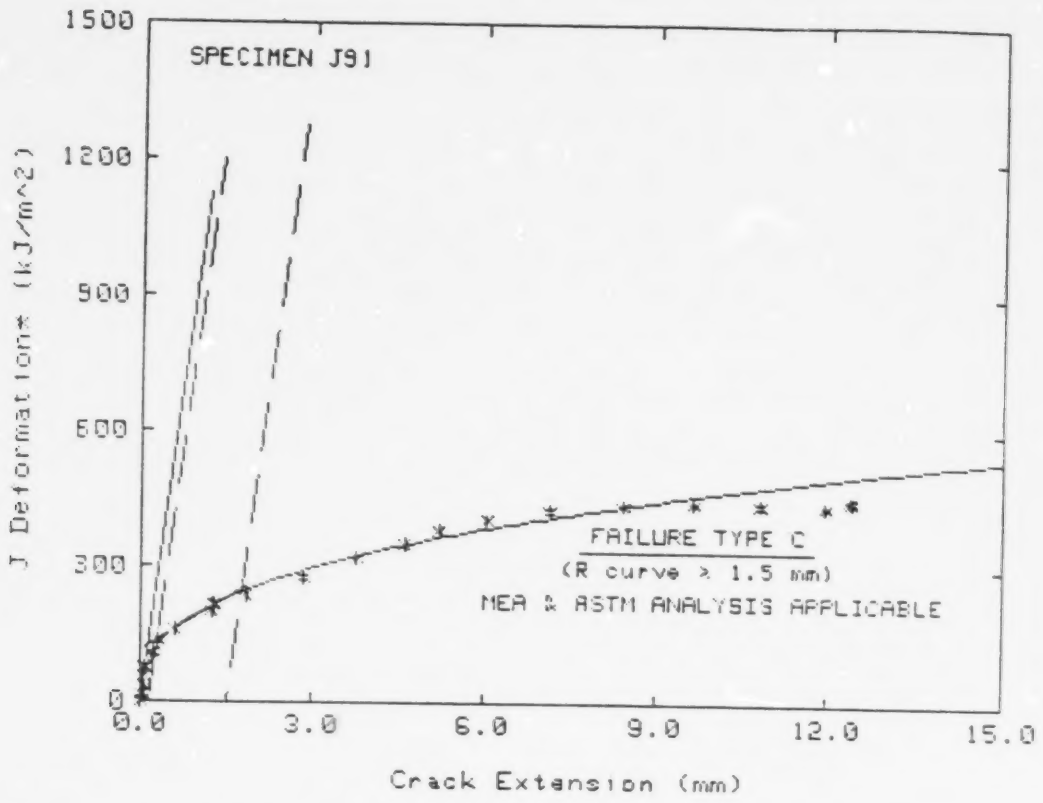
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 488 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 124.1 kJ/m^2
Kjc	= 154.7 MPa √m
J (@J/T=8.8)	= 283.3 kJ/m^2
Exponent N	= .3511
Coefficient C	= 194.1 kJ/m^2
T (average)	= 58

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 122.2 kJ/m^2	
Kjc	= 153.5 MPa √m	
Slope M	= 77573.7 kJ/m^3	
Intercept B	= 112.5 kJ/m^2	
T (ASTM)	= 63	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 495.5 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 0



TEST SPECIMEN DATA

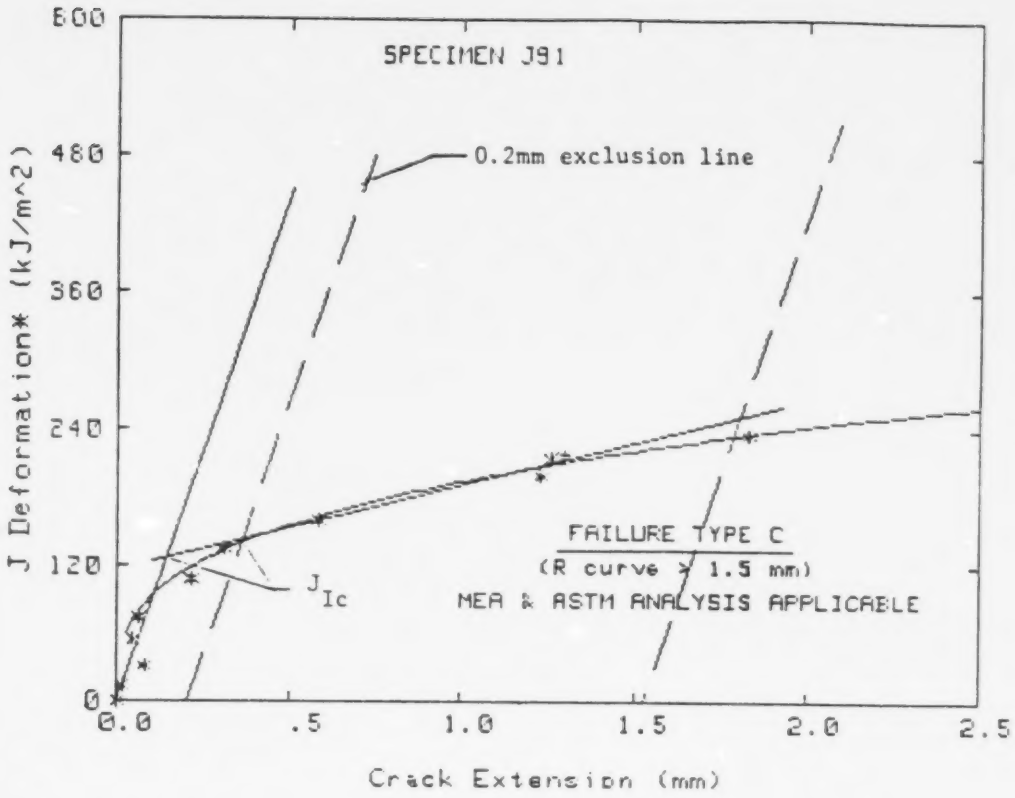
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 488 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 283.3 kJ/m^2
Jic	= 120.8 kJ/m^2
Kjc	= 152.7 MPa √m
Exponent N	= .3759
Coefficient C	= 196 kJ/m^2
T (average)	= 63

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 122.2 kJ/m^2	
Kjc	= 153.5 MPa √m	
Slope M	= 77573.7 kJ/m^3	
Intercept B	= 112.5 kJ/m^2	
T (ASTM)	= 63	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 495.5 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 6



TEST SPECIMEN DATA

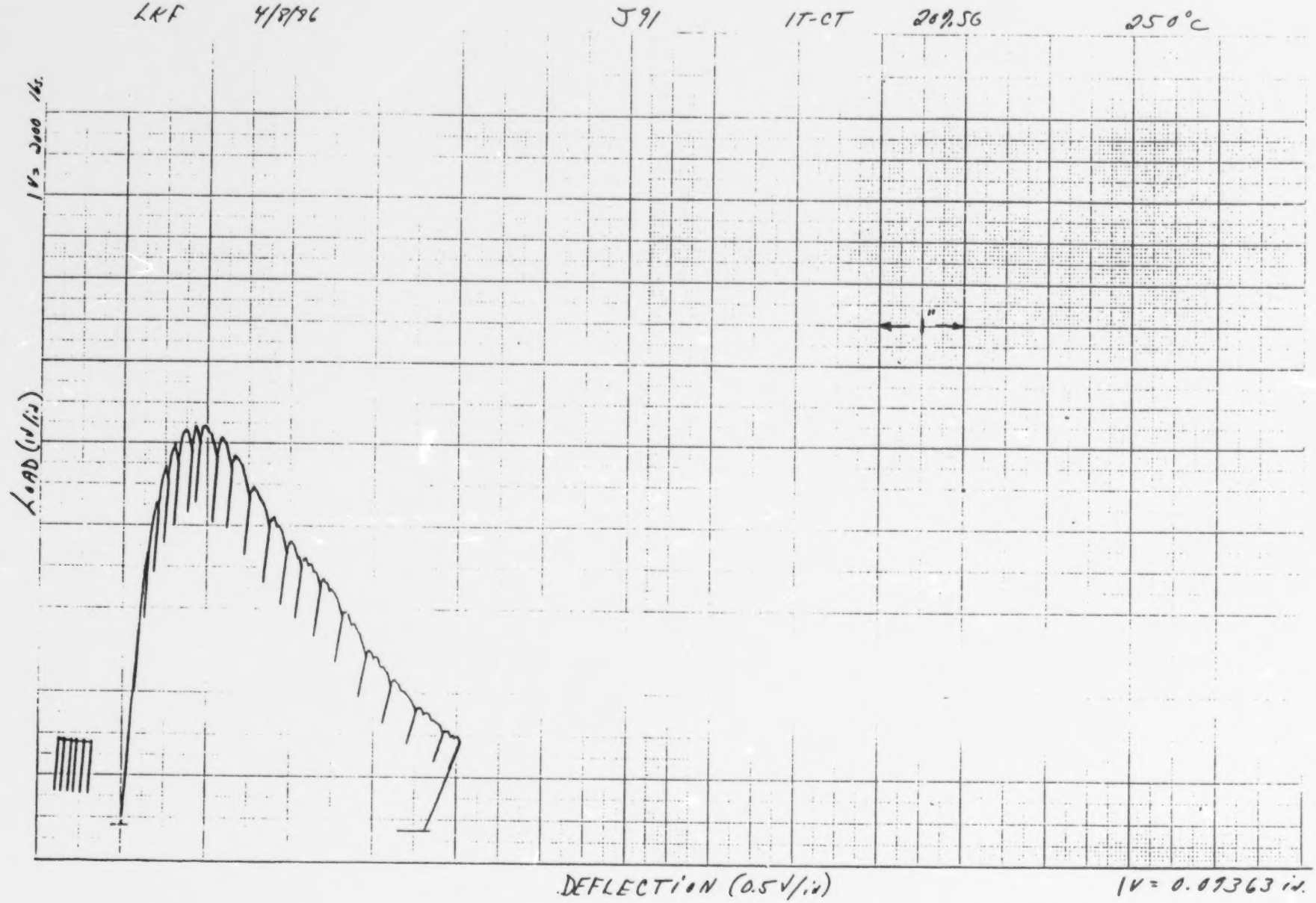
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Init crack length	= 27.3 mm	Init a/W = .537
Final crack length	= 39.88 mm	Final a/W = .784
Flow stress	= 448 MPa	
Youngs modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 139.5 kJ/m^2	
Kjc	= 164.1 MPa √m	
J (@J/T=8.8)	= 283.3 kJ/m^2	
Exponent N	= .3202	
Coefficient C	= 194.3 kJ/m^2	
T (average)	= 61	

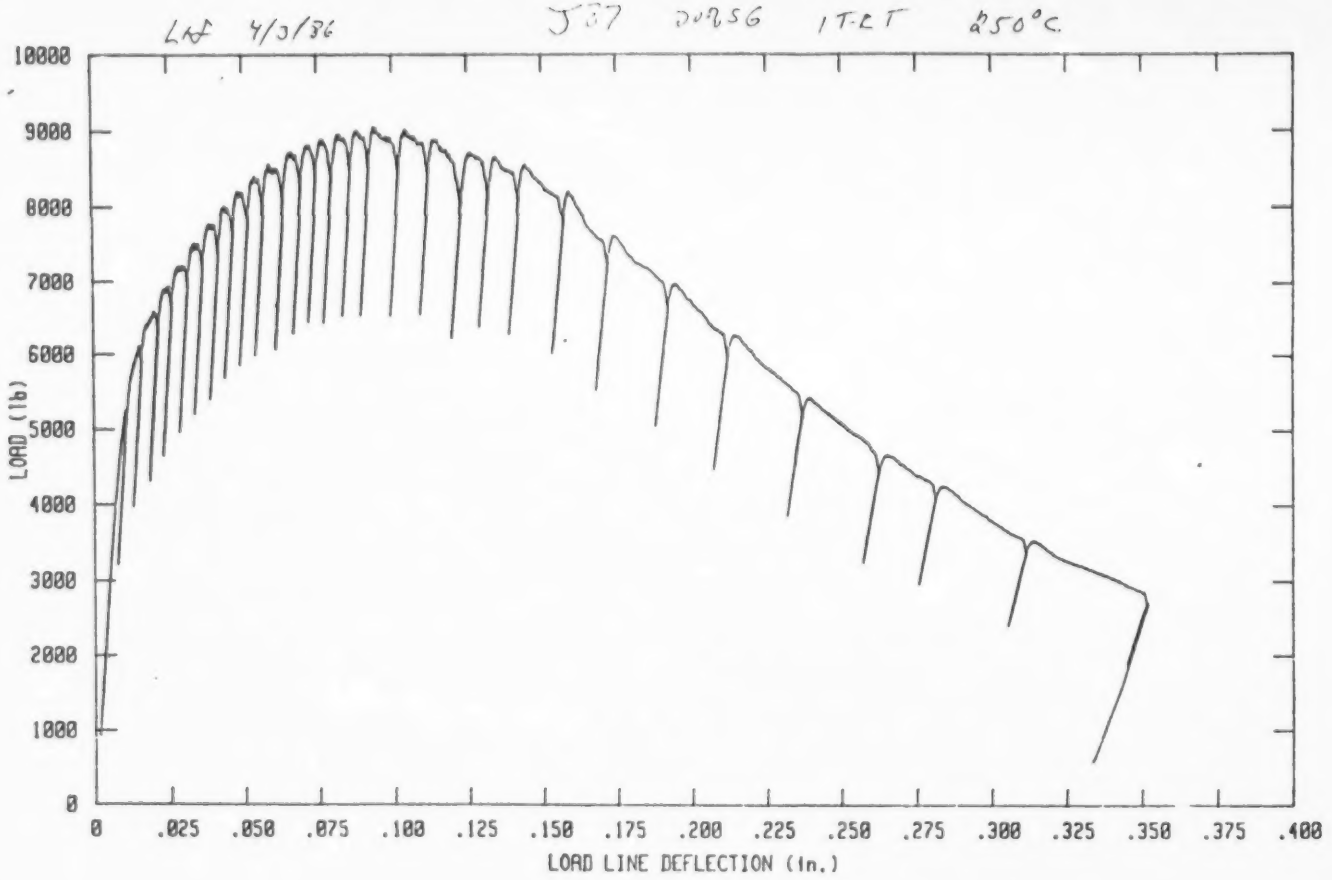
LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

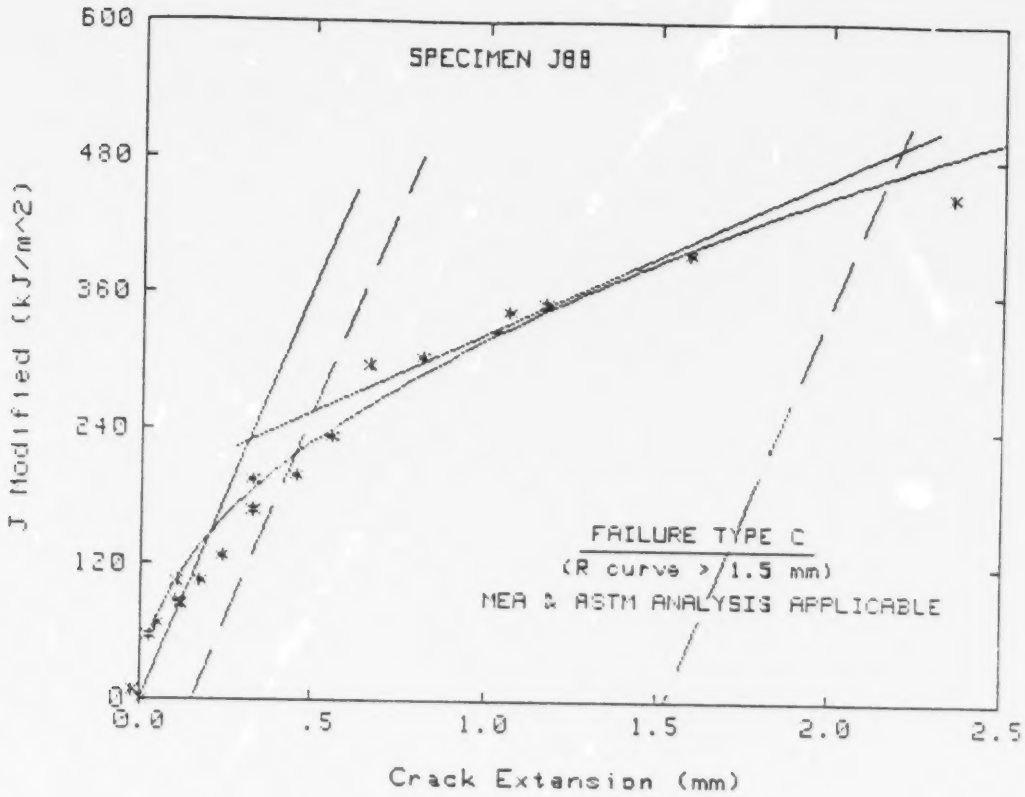
Jic	= 126.9 kJ/m^2	
Kjc	= 156.4 MPa √m	
Slope M	= 74389.7 kJ/m^3	
Intercept B	= 116.3 kJ/m^2	
T (ASTM)	= 72	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.9 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	


LKF 4/8/96 J91 IT-CT 209.56 250°C
1V = 3000 lbs.
LOAD (1V/in)
1"
DEFLECTION (0.5V/in)
1V = 0.09363 in.

87-262

71


LAF 4/3/86
J37 2025G 1T-LT 250°C.
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
LOAD (lb)
0
.025
.050
.075
.100
.125
.150
.175
.200
.225
.250
.275
.300
.325
.350
.375
.400
LOAD LINE DEFLECTION (in.)



TEST SPECIMEN DATA

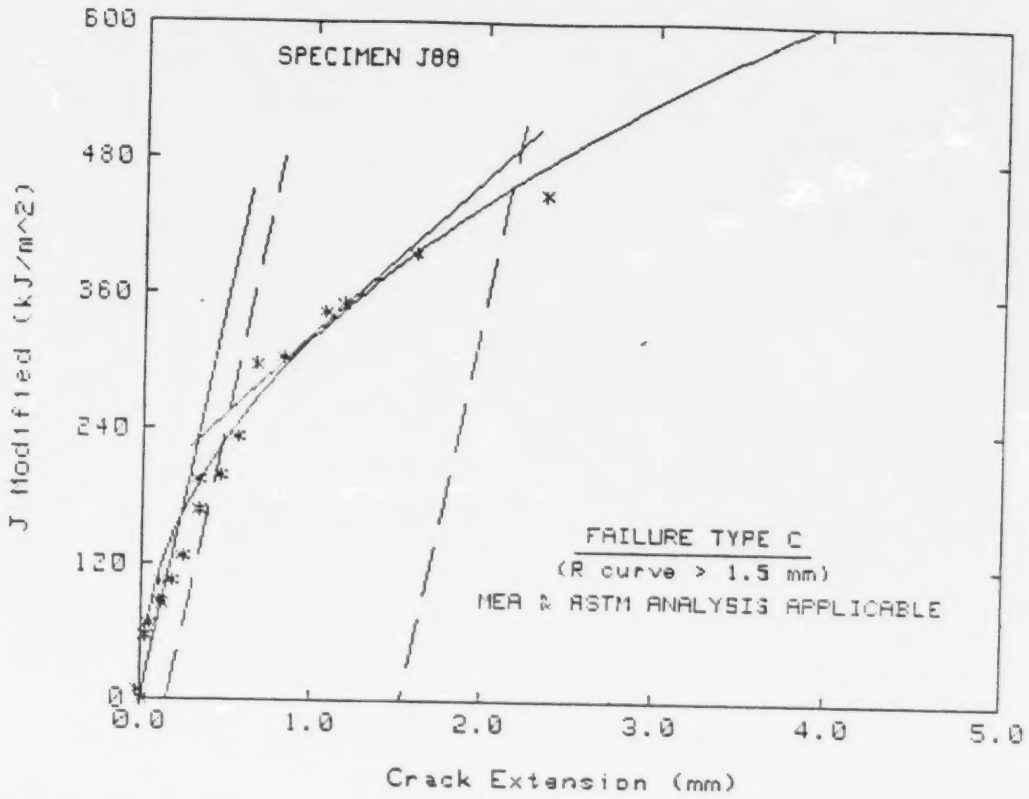
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.67 mm	Init a/W = .525
Final Crack Length	= 28.96 mm	Final a/W = .57
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 216.3 kJ/m^2
Kjc	= 204.2 MPa √m
J (@J/T=8.8)	= 718 kJ/m^2
Exponent N	= .4866
Coefficient C	= 319.2 kJ/m^2
T (average)	= 204

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 228.3 kJ/m^2	
Kjc	= 209.9 MPa √m	
Slope M	= 139488 kJ/m^3	
Intercept B	= 184.6 kJ/m^2	
T (ASTM)	= 203	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.41 mm	(Delta a max = 0.1*bo)
Final Delta a	= 2.36 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 2	Points Right = 1



TEST SPECIMEN DATA

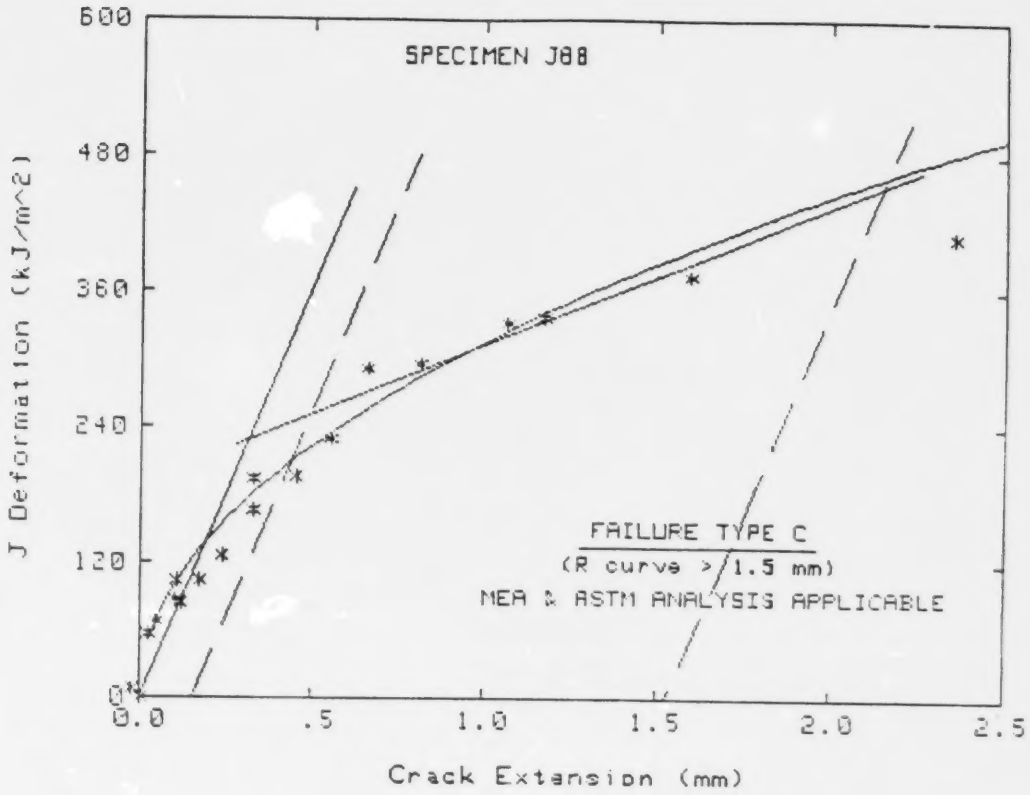
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.67 mm	Init a/W = .525
Final Crack Length	= 28.96 mm	Final a/W = .57
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 718 kJ/m^2
Jic	= 225.5 kJ/m^2
Kjc	= 208.6 MPa √m
Exponent N	= .4574
Coefficient C	= 321 kJ/m^2
T (average)	= 192

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 228.3 kJ/m^2	
Kjc	= 209.9 MPa √m	
Slope M	= 139488 kJ/m^3	
Intercept B	= 184.6 kJ/m^2	
T (ASTM)	= 203	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.41 mm	(Delta a max = 0.1*bo)
Final Delta a	= 2.36 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 1



TEST SPECIMEN DATA

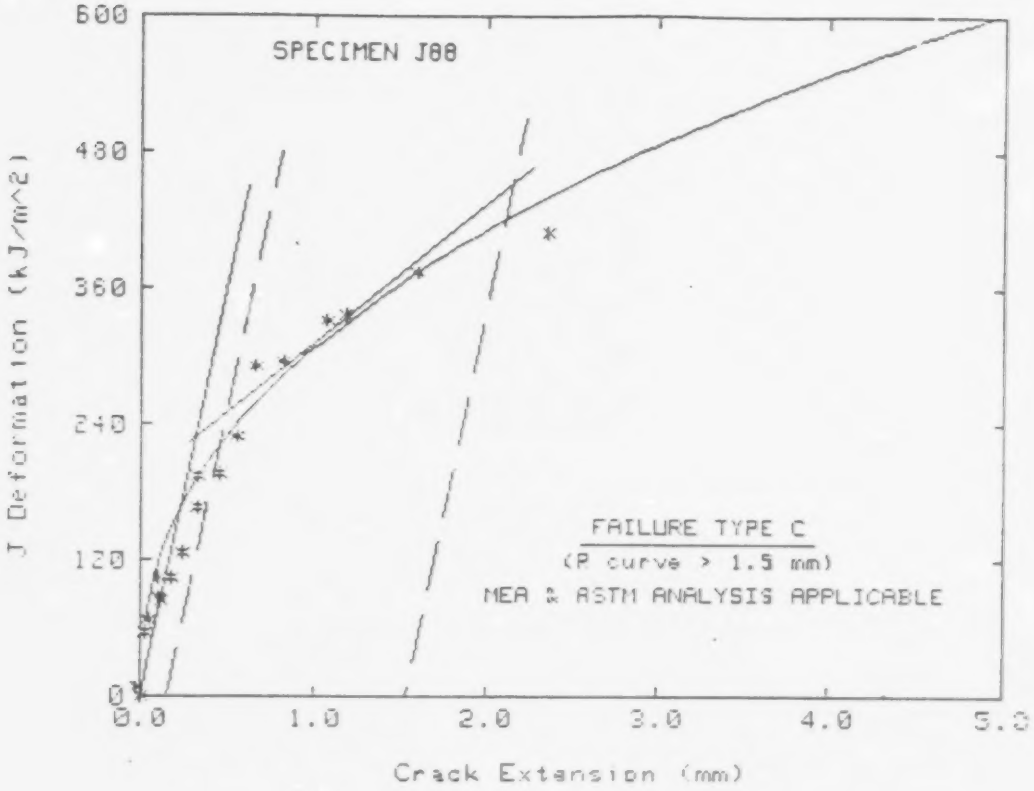
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.67 mm	Init a/W = .525
Final Crack Length	= 28.96 mm	Final a/W = .57
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 209.3 kJ/m^2
Kjc	= 200.9 MPa √m
J (@J/T=8.8)	= 619 kJ/m^2
Exponent N	= .4971
Coefficient C	= 314.9 kJ/m^2
T (average)	= 207

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 228.9 kJ/m^2	
Kjc	= 210.1 MPa √m	
Slope M	= 121885.2 kJ/m^3	
Intercept B	= 190.6 kJ/m^2	
T (ASTM)	= 177	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.41 mm	(Delta a max = 0.1*bo)
Final Delta a	= 2.36 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 2	Points Right = 0



TEST SPECIMEN DATA

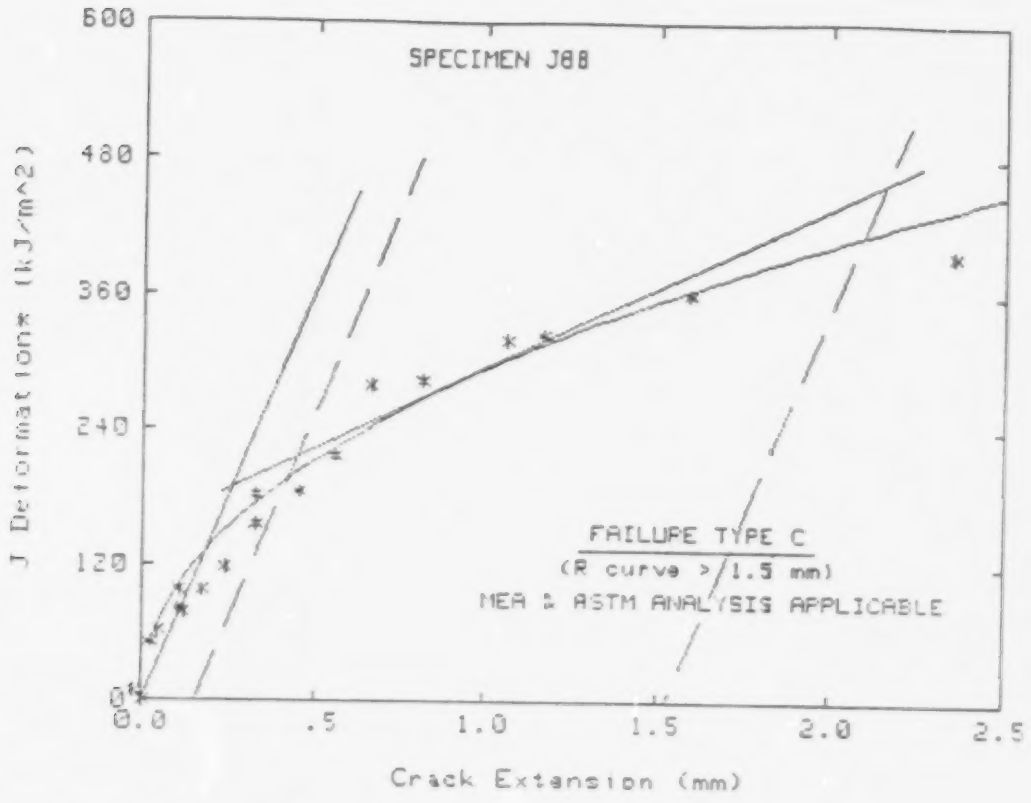
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.67 mm	Init a/W = .525
Final Crack Length	= 28.96 mm	Final a/W = .57
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 619 kJ/m^2
Jic	= 221.8 kJ/m^2
Kjc	= 206.8 MPa √m
Exponent N	= .4183
Coefficient C	= 307.8 kJ/m^2
T (average)	= 169

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 228.9 kJ/m^2	
Kjc	= 210.1 MPa √m	
Slope M	= 121885.2 kJ/m^3	
Intercept B	= 190.6 kJ/m^2	
T (ASTM)	= 177	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.41 mm	(Delta a max = 0.1*bo)
Final Delta a	= 2.36 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 1



TEST SPECIMEN DATA

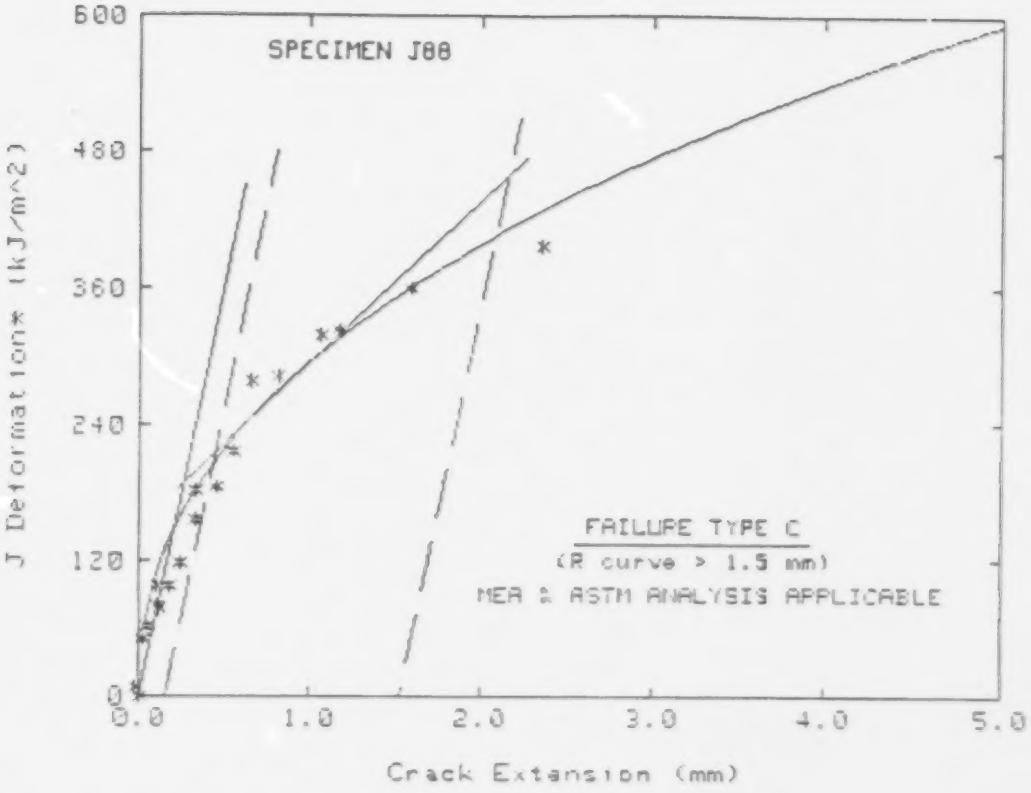
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.67 mm	Init a/W = .525
Final Crack Length	= 28.96 mm	Final a/W = .57
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 196 kJ/m^2
Kjc	= 194.4 MPa √m
J (@J/T=8.8)	= 619 kJ/m^2
Exponent N	= .4657
Coefficient C	= 293.1 kJ/m^2
T (average)	= 183

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 188.7 kJ/m^2	
Kjc	= 190.8 MPa √m	
Slope M	= 143345.7 kJ/m^3	
Intercept B	= 151.5 kJ/m^2	
T (ASTM)	= 208	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.41 mm	(Delta a max = 0.1*bo)
Final Delta a	= 2.36 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 2	Points Right = 1



TEST SPECIMEN DATA

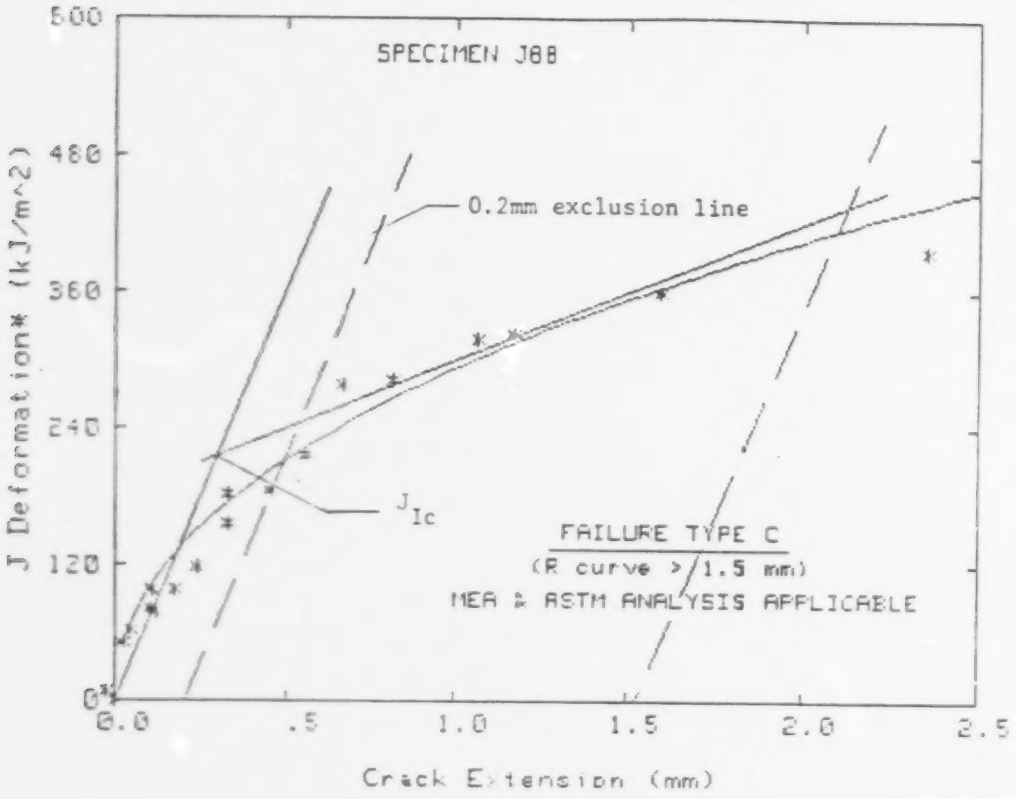
Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 26.67 mm	Init a/W = .525
Final Crack Length	= 28.96 mm	Final a/W = .57
Flow Stress	= 364.6 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 619 kJ/m^2
Jic	= 205.2 kJ/m^2
Kjc	= 199 MPa √m
Exponent N	= .4342
Coefficient C	= 294.9 kJ/m^2
T (average)	= 171

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 188.7 kJ/m^2	
Kjc	= 190.8 MPa √m	
Slope M	= 143345.7 kJ/m^3	
Intercept B	= 151.5 kJ/m^2	
T (ASTM)	= 208	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.41 mm	(Delta a max = 0.1*bo)
Final Delta a	= 2.36 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 1



TEST SPECIMEN DATA

Material Type	= SA-106B (PIPE #N5)	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Init crack length	= 26.67 mm	Init a/W = .525
Final crack length	= 28.96 mm	Final a/W = .57
Flow stress	= 364.6 MPa	
Youngs modulus	= 192900 MPa	(Estimated Value)

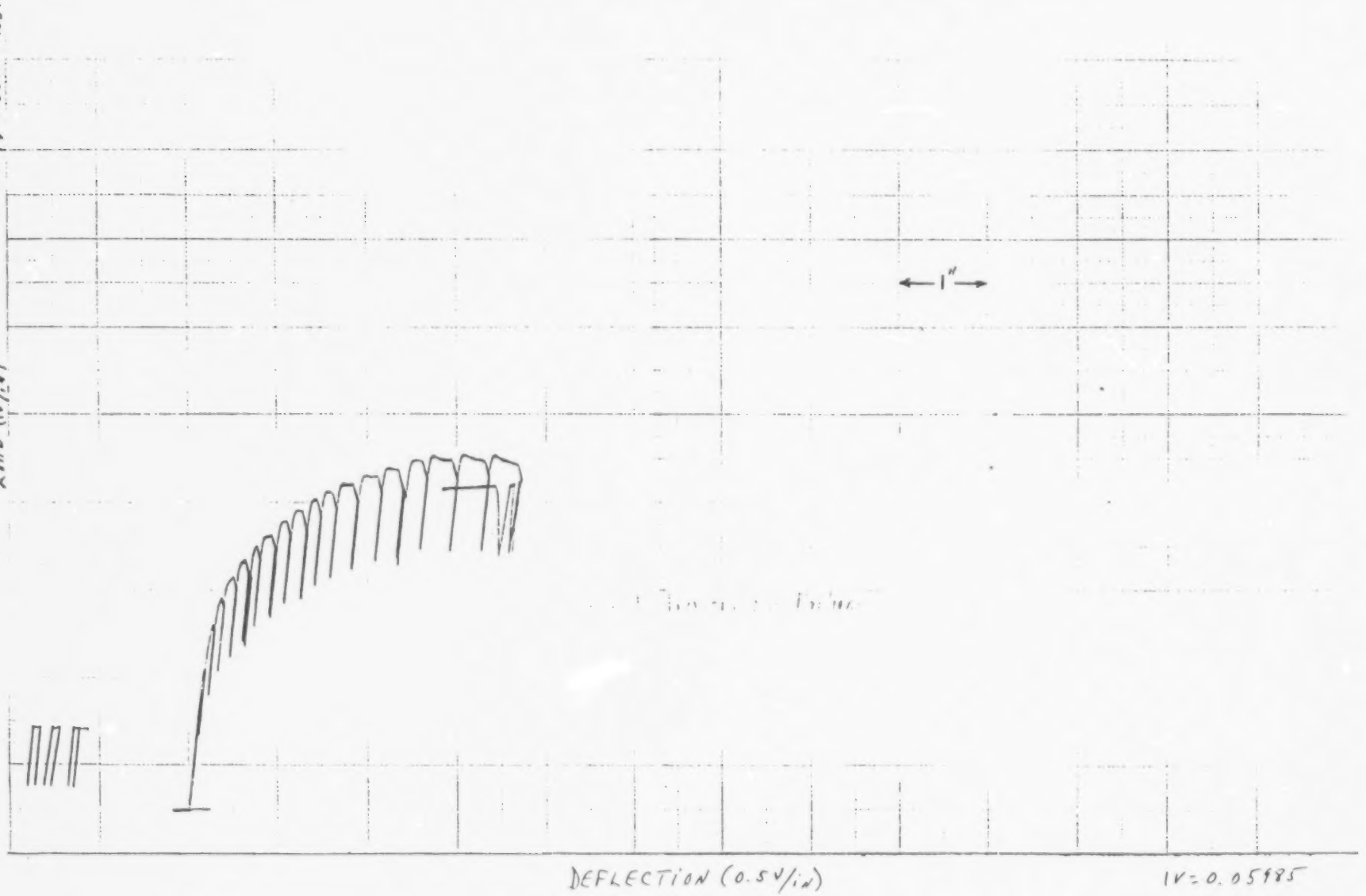
POWER LAW DATA J = C (Delta a) ^ N

Jic	= 209.8 kJ/m^2
Kjc	= 201.2 MPa √m
J (0J/T=8.8)	= 618.9 kJ/m^2
Exponent N	= .4657
Coefficient C	= 293.1 kJ/m^2
T (average)	= 179

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 214.3 kJ/m^2	
Kjc	= 203.3 MPa √m	
Slope M	= 120781.2 kJ/m^3	
Intercept B	= 178.8 kJ/m^2	
T (ASTM)	= 175	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 370.2 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.41 mm	(Delta a max = 0.1*bo)
Final Delta a	= 2.36 mm	
Poisson's Ratio (v)	= 0	

LNF 3/29/86 J88 IT-CT 20%SG 25.0°C



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87-262

MATERIALS ENGINEERING ASSOCIATES, INC.
STRUCTURAL INTEGRITY TECHNOLOGY
CORROSION FATIGUE • FRACTURE MECHANICS TESTING • IRRADIATIONS

June 24, 1986

Mr. B. Mukherjee
Ontario Hydro
800 Kiling Avenue
Toronto, Ontario M8Z 5SZ
Canada

Dear Mr. Mukerjee:

Enclosed are the additional J* data tables you requested in your letter dated June 4, 1986. Also included are a revised set of plot/data sheets for specimen J91. Apparently the flow stress for this specimen test was input incorrectly in the original copies sent to you. This error does not have any substantial effect on the J-R curve results, however. I have also included revised copies of Tables 1 and 2 which summarized initiation fracture toughness and tearing modulus results.

I hope this oversight on my part does not cause you any inconvenience and if there is any additional information you require give me a call.

Sincerely,

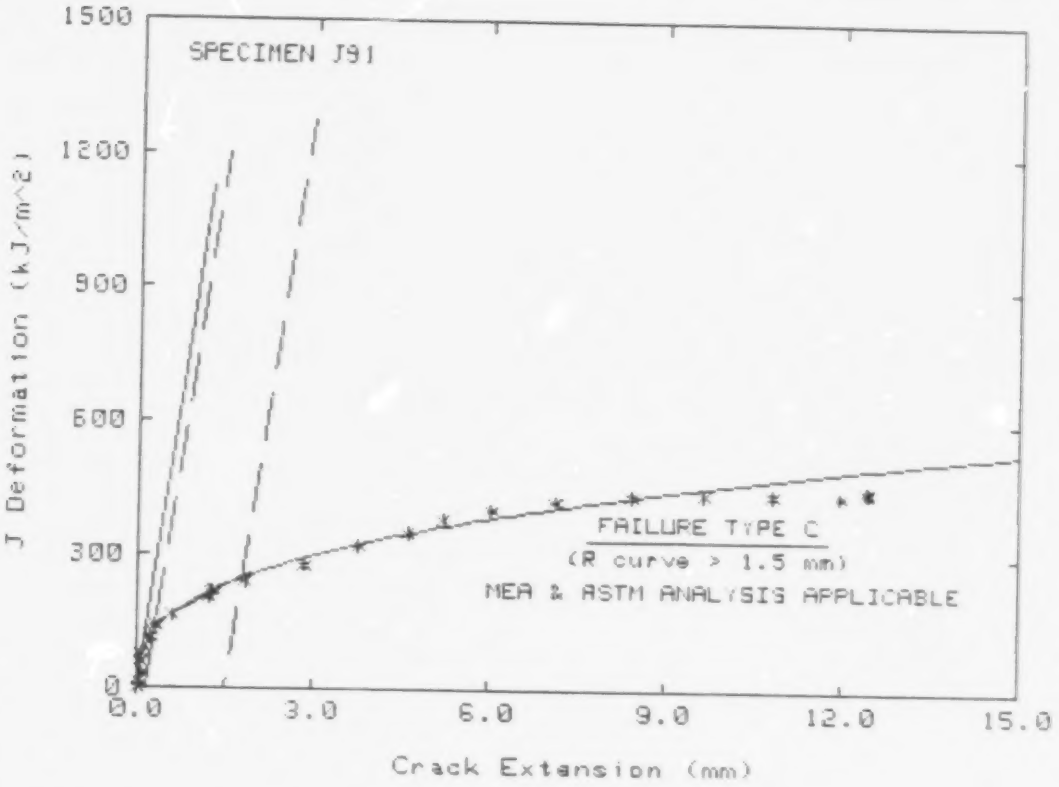
Blain Menke

Blain Menke
Senior Engineer

Enclosure

BM/dlc:MUK-60624

9700-B GEORGE PALMER HIGHWAY, LANHAM, MARYLAND 20706-1837 USA • (301) 577-9490



TEST SPECIMEN DATA

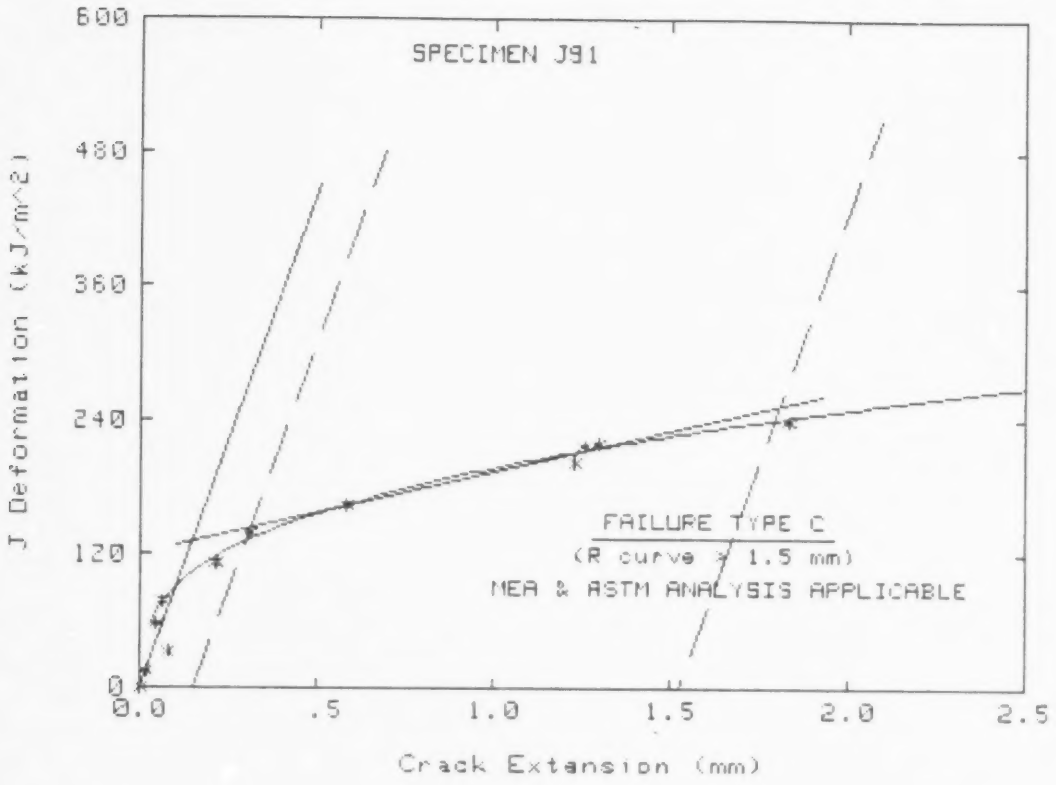
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 300 kJ/m^2
Jic	= 128 kJ/m^2
Kjc	= 157.1 MPa √m
Exponent N	= .3641
Coefficient C	= 199.6 kJ/m^2
T (average)	= 72

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 131.8 kJ/m^2	
Kjc	= 159.4 MPa √m	
Slope M	= 73197 kJ/m^3	
Intercept B	= 121 kJ/m^2	
T (ASTM)	= 70	
Validity (Jic)	= INVALID--b	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 6



TEST SPECIMEN DATA

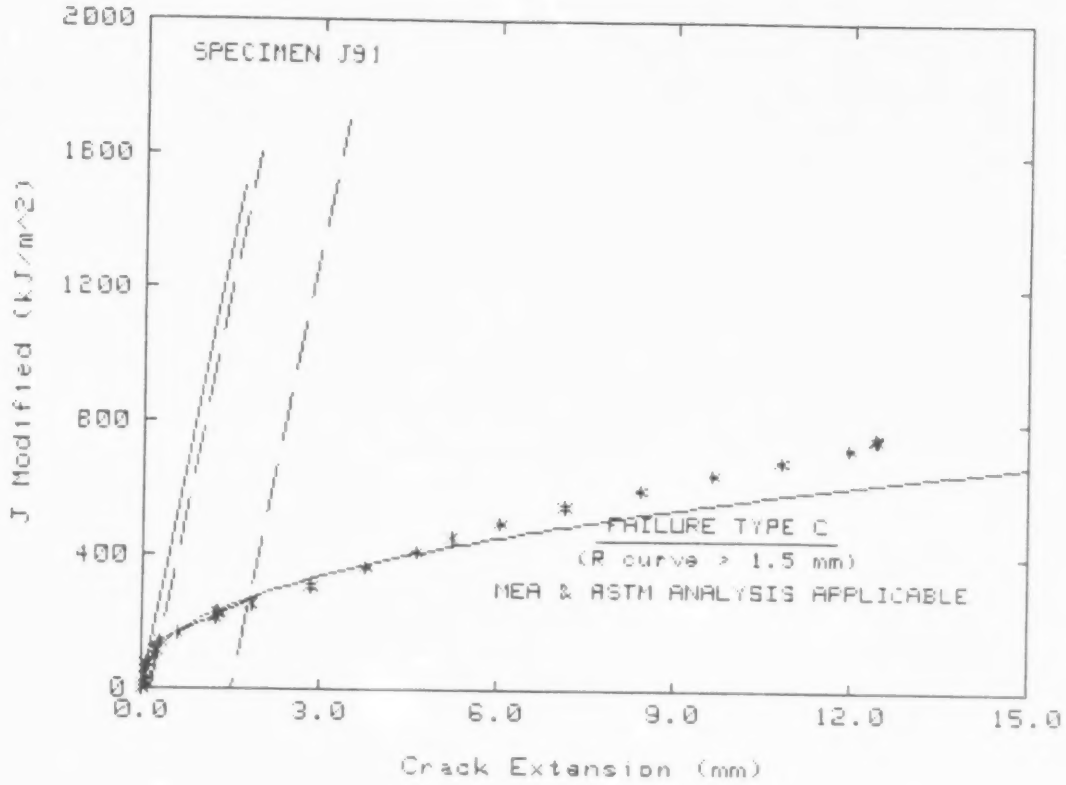
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 131 kJ/m^2
Kjc	= 159 MPa √m
J (@J/T=8.8)	= 300 kJ/m^2
Exponent N	= .3399
Coefficient C	= 197.6 kJ/m^2
T (average)	= 67

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 131.8 kJ/m^2	
Kjc	= 159.4 MPa √m	
Slope M	= 73197 kJ/m^3	
Intercept B	= 121 kJ/m^2	
T (ASTM)	= 70	
Validity (Jic)	= INVALID--b	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 0



TEST SPECIMEN DATA

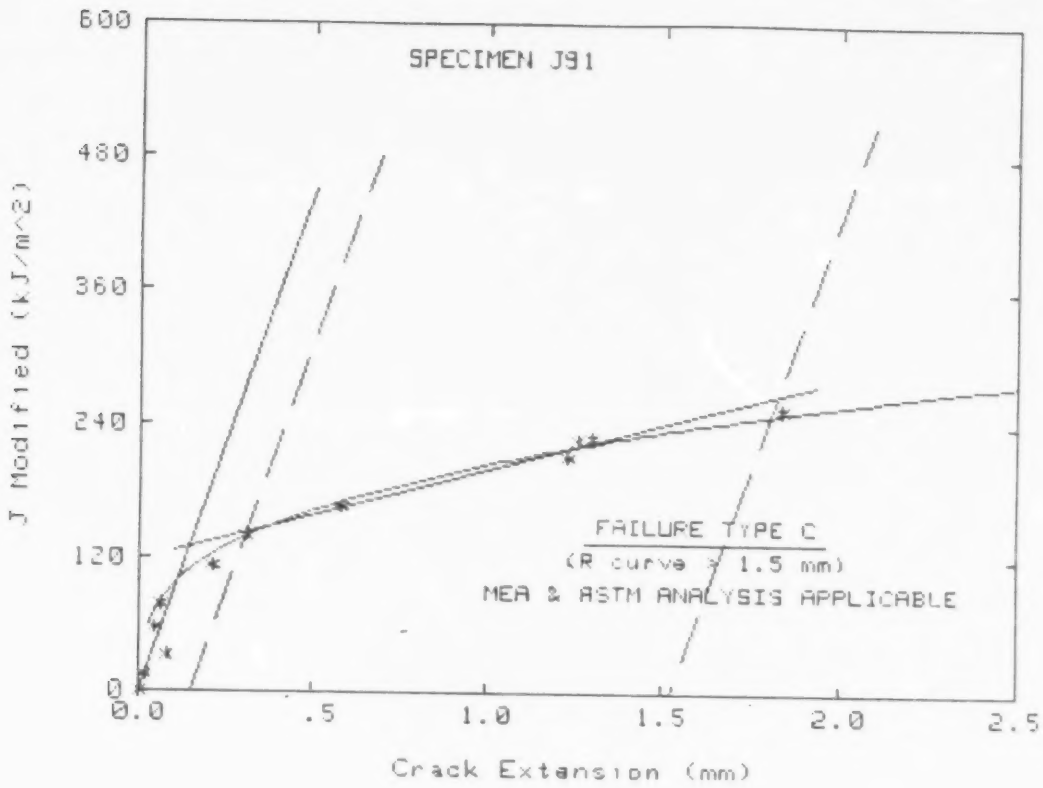
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 364.9 kJ/m^2
Jic	= 123.1 kJ/m^2
Kjc	= 154.1 MPa √m
Exponent N	= .4304
Coefficient C	= 209.7 kJ/m^2
T (average)	= 89

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 130.8 kJ/m^2	
Kjc	= 158.8 MPa √m	
Slope M	= 82063.5 kJ/m^3	
Intercept B	= 118.8 kJ/m^2	
T (ASTM)	= 79	
Validity (Jic)	= INVALID--b	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 6



TEST SPECIMEN DATA

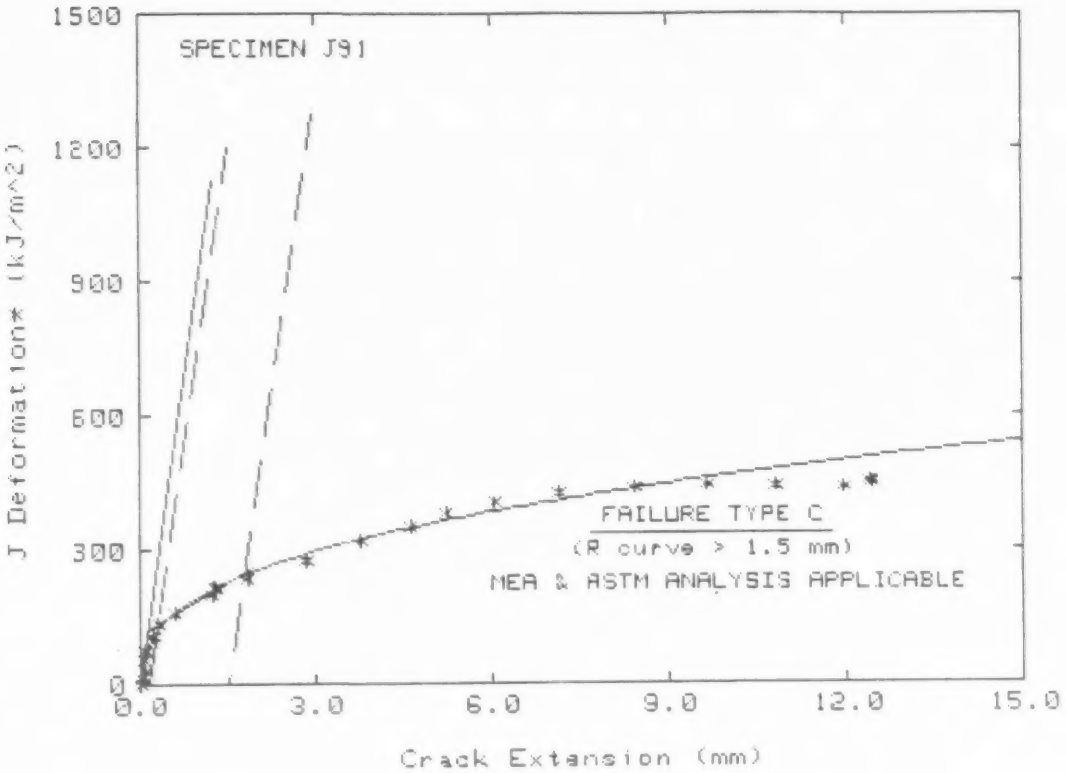
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 138.4 kJ/m^2
Kjc	= 163.4 MPa √m
J (@J/T=8.8)	= 364.9 kJ/m^2
Exponent N	= .332
Coefficient C	= 204.9 kJ/m^2
T (average)	= 68

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 130.8 kJ/m^2	
Kjc	= 158.8 MPa √m	
Slope M	= 82063.5 kJ/m^3	
Intercept B	= 118.8 kJ/m^2	
T (ASTM)	= 79	
Validity (Jic)	= INVALID--b	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet+Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 0



TEST SPECIMEN DATA

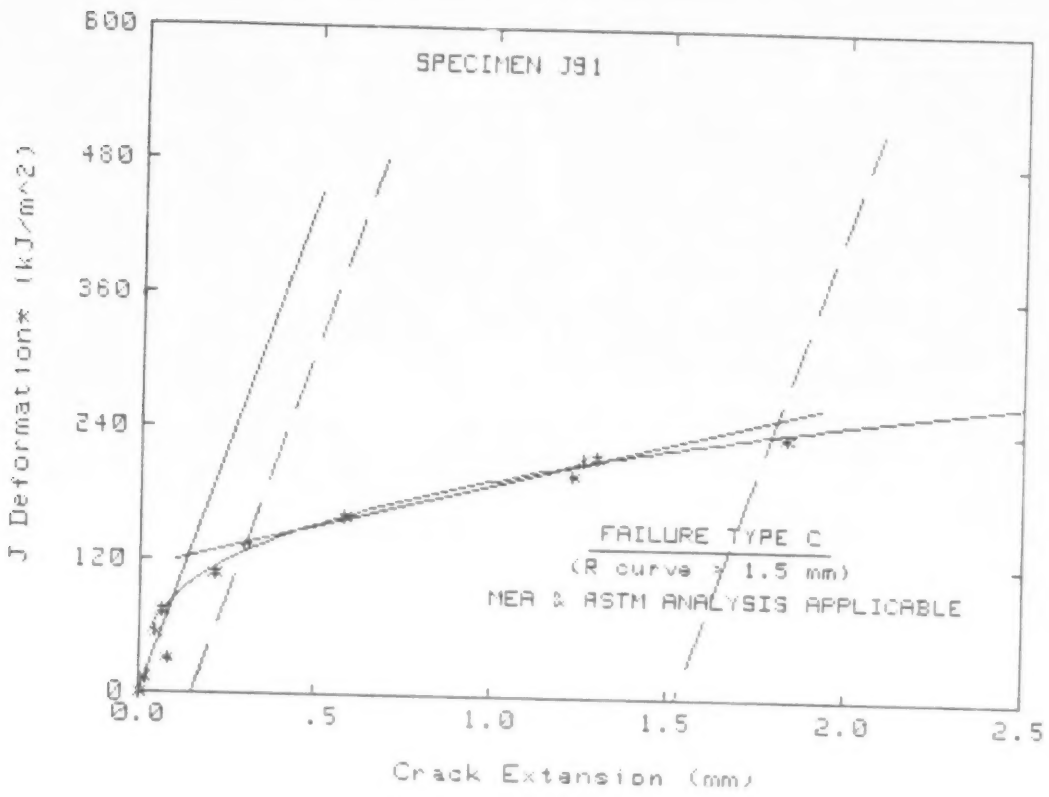
Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

J (@J/T=8.8)	= 302.1 kJ/m^2
Jic	= 123 kJ/m^2
Kjc	= 154 MPa √m
Exponent N	= .3759
Coefficient C	= 196 kJ/m^2
T (average)	= 74

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 123.2 kJ/m^2	
Kjc	= 154.1 MPa √m	
Slope M	= 77573.7 kJ/m^3	
Intercept B	= 112.5 kJ/m^2	
T (ASTM)	= 75	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 6



TEST SPECIMEN DATA

Material Type	= WELD	
Test Temperature	= 250 C	
Percent Side Groove	= 20 %	
Specimen Thickness	= 25.4 mm	
Initial Crack Length	= 27.3 mm	Init a/W = .537
Final Crack Length	= 39.88 mm	Final a/W = .785
Flow Stress	= 448 MPa	
Youngs Modulus	= 192900 MPa	(Estimated Value)

POWER LAW DATA J = C (Delta a) ^ N

Jic	= 126.2 kJ/m^2
Kjc	= 156 MPa √m
J (@J/T=8.8)	= 302.1 kJ/m^2
Exponent N	= .3511
Coefficient C	= 194.1 kJ/m^2
T (average)	= 68

LEAST SQUARE LINEAR LINE (ASTM) J = M (Delta a) + B

Jic	= 123.2 kJ/m^2	
Kjc	= 154.1 MPa √m	
Slope M	= 77573.7 kJ/m^3	
Intercept B	= 112.5 kJ/m^2	
T (ASTM)	= 75	
Validity (Jic)	= VALID	
Validity (R-curve)	= INVALID--2	
J maximum allowed	= 454.8 kJ/m^2	(Jmax=Bnet*Flow stress/20)
Delta a max. allowed	= 2.35 mm	(Delta a max = 0.1*bo)
Final Delta a	= 12.42 mm	
Poisson's Ratio (v)	= 0	
Points Left	= 1	Points Right = 0

SPECIMEN # J91
(Modified J Integral)

Unload Number	Jm (kJ/m^2)	Delta A (mm)	Load (kN)	Deflection (mm)
0	0.0	0.0000	0.0000	0.0000
1	15.3	.0152	24.4376	.2560
2	32.7	.0782	32.8190	.3847
3	57.2	.0445	37.3828	.5293
4	77.8	.0621	41.9645	.6382
5	113.0	.2129	42.4360	.8144
6	140.9	.3094	45.9857	.9459
7	167.1	.5801	46.5017	1.0717
8	211.2	1.2285	45.6832	1.2822
9	226.8	1.2557	42.1602	1.3545
10	228.7	1.2973	42.6495	1.3640
11	254.8	1.8336	44.8292	1.4917
12	306.2	2.8315	41.6353	1.7493
13	365.2	3.7613	37.7743	2.0537
14	412.0	4.6073	35.0253	2.3105
15	455.1	5.2192	32.4898	2.5491
16	498.2	6.0400	30.7639	2.8035
17	547.6	7.1228	27.7213	3.1155
18	599.2	8.4271	22.7873	3.4818
19	644.3	9.6507	19.5393	3.8404
20	685.2	10.8233	16.7796	4.1995
21	724.9	11.9690	14.6756	4.5638
22	752.7	12.4322	13.5261	4.8308
23	756.2	12.4180	12.9221	4.8584
24	756.5	12.4156	12.8678	4.8610

SPECIMEN # J91
(Deformation J Integral)

Unload Number	Jd (kJ/m^2)	Delta A (mm)	Load (kN)	Deflection (mm)
0	0.0	0.0000	0.0000	0.0000
1	15.3	.0152	24.4376	.2560
2	32.6	.0782	32.8190	.3847
3	57.2	.0445	37.3828	.5293
4	77.8	.0621	41.9645	.6382
5	112.4	.2129	42.4360	.8144
6	139.7	.3094	45.9857	.9459
7	164.1	.5801	46.5017	1.0717
8	202.6	1.2285	45.6832	1.2822
9	217.9	1.2557	42.1602	1.3545
10	219.3	1.2973	42.6495	1.3640
11	239.5	1.8336	44.8292	1.4917
12	277.3	2.8315	41.6353	1.7493
13	320.5	3.7613	37.7743	2.0537
14	350.8	4.6073	35.0253	2.3105
15	380.1	5.2192	32.4898	2.5491
16	403.1	6.0400	30.7639	2.8035
17	423.3	7.1228	27.7213	3.1155
18	436.2	8.4271	22.7873	3.4818
19	441.7	9.6507	19.5393	3.8404
20	441.8	10.8233	16.7796	4.1995
21	438.9	11.9690	14.6756	4.5838
22	447.6	12.4322	13.5261	4.8308
23	451.8	12.4180	12.9221	4.8589
24	452.2	12.4156	12.8678	4.8610

SPECIMEN # J91
(Modified J Integral)

Unload Number	Jm (lb/in)	Delta A (in)	Load (lb)	Deflection (in)
0	0.0	0.0000	0.0	0.0000
1	87.3	.0006	5493.8	.0101
2	186.5	.0031	7378.0	.0151
3	326.6	.0018	8404.0	.0208
4	444.5	.0024	9434.0	.0251
5	645.4	.0084	9540.0	.0321
6	804.5	.0122	10338.0	.0372
7	954.1	.0228	10454.0	.0422
8	1206.2	.0484	10270.0	.0505
9	1295.1	.0494	9478.0	.0533
10	1305.8	.0511	9588.0	.0537
11	1455.1	.0722	10078.0	.0587
12	1748.5	.1115	9360.0	.0689
13	2085.3	.1481	8492.0	.0809
14	2352.7	.1814	7874.0	.0910
15	2598.5	.2055	7304.0	.1004
16	2845.0	.2378	6916.0	.1104
17	3126.7	.2804	6232.0	.1227
18	3421.6	.3318	5122.8	.1371
19	3679.2	.3799	4392.6	.1512
20	3912.9	.4261	3772.2	.1653
21	4139.0	.4712	3299.2	.1803
22	4297.8	.4895	3040.8	.1902
23	4318.0	.4889	2905.0	.1913
24	4319.5	.4888	2892.8	.1914

SPECIMEN # J91
(Deformation J Integral)

Unload Number	Jd (lb/in)	Delta A (in)	Load (lb)	Deflection (in)
0	0.0	0.0000	0.0	0.0000
1	87.3	.0006	5493.8	.0101
2	186.3	.0031	7378.0	.0151
3	326.7	.0018	8404.0	.0208
4	444.3	.0024	9434.0	.0251
5	641.7	.0084	9540.0	.0321
6	797.8	.0122	10338.0	.0372
7	937.1	.0228	10454.0	.0422
8	1156.7	.0484	10270.0	.0505
9	1244.0	.0494	9478.0	.0533
10	1252.2	.0511	9588.0	.0537
11	1367.6	.0722	10078.0	.0587
12	1583.6	.1115	9360.0	.0689
13	1830.3	.1481	8492.0	.0809
14	2002.9	.1814	7874.0	.0910
15	2170.2	.2055	7304.0	.1004
16	2301.9	.2378	6916.0	.1104
17	2417.3	.2804	6232.0	.1227
18	2490.8	.3318	5122.8	.1371
19	2522.0	.3799	4392.6	.1512
20	2522.6	.4261	3772.2	.1652
21	2506.3	.4712	3299.2	.1805
22	2556.1	.4895	3040.8	.1902
23	2579.9	.4889	2905.0	.1913
24	2582.0	.4888	2892.8	.1914

Table 1 J-Integral Fracture Toughness Data Summary for SA 106 Sch. 100 Pipe and Weld[a]

Specimen Number	$(a/w)_i$[b]	a_m[c]	$a_p - a_m$[d]	J_{Ic}							ASTM E 813 Validity	Flow Stress
				Power Law (0.15 mm)[e]			Current ASTM E 813[f]			Proposed[g]		
				J_M	J_D	J_*	J_M	J_D	J_*	J_*		
		(mm)	(mm)	(kJ/m^2)	(kJ/m^2)	(kJ/m^2)	(kJ/m^2)	(kJ/m^2)	(kJ/m^2)	(kJ/m^2)		(MPa)
J86(N5)	0.512	13.08	-0.33	194.9	197.4	195.1	178.4	178.1	181.5	204.1	Valid	364.6
J87(N5)	0.520	13.48	-0.72	306.5	296.8	275.9	292.4	290.6	272.2	283.7	Valid	364.6
J88(N5)[h]	0.525	2.29	+0.13	216.3	209.3	196.0	228.3	228.9	188.7	209.8	Valid	364.6
J89(C5)[i]	0.501	12.73	-0.23	176.6	176.0	171.5	165.1	167.2	162.7	183.4	——[i]	448.0
J90(C5)[i]	0.507	12.89	-0.40	185.0	181.8	174.5	176.4	177.5	170.2	186.4	——[i]	448.0
J91(C8)	0.537	12.58	-0.16	138.4	131.0	126.2	130.8	131.8	123.2	143.0	Valid	448.0

[a] Testing conducted at 250°C, ASTM Standard E 399 specimen orientation LC, side grooved 10% of thickness on each side

[b] Initial a/W

[c] Measured crack extension

[d] Difference between measured and predicted crack extension

[e] J_{Ic} for the three formulations of the J integral determined at the intersection of the power-law regression and 0.15-mm exclusion line

[f] J_{Ic} for the three formulations of the J integral determined at the intersection of linear regression and the blunting line

[g] J_{Ic} determined at the intersection of the power-law regression and the 0.2-mm exclusion line for J_* data

[h] Equipment failure terminated test at Δa = 2.29-mm crack extension, just beyond the second exclusion line

[i] Nonuniform precrack: one of nine measurements is less than the 1.27 mm required by E 813; however, the average is > 1.27 mm

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Table 2 Tearing Modulus Summary

Specimen Number	E 813[a]			MEA[b]		
	J_M	J_D	J_*	J_M	J_D	J_*
J86(N5)	181	164	160	170	142	144
J87(N5)	168	137	139	153	146	150
J88(N5)	203	177	208	204	207	183
J89(C5)	125	111	111	117	105	104
J90(C5)	128	116	113	115	105	104
J91(C8)	79	70	75	89	72	74

[a] Values tabulated were obtained using the ASTM E 813 procedure

[b] Values tabulated were obtained by fitting a linear least-square regression to the power-law equation between the 0.15-mm and 1.5-mm exclusion lines.

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